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ELECTRICAL ENGINEERING

APRIL 1954

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

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VOLTAGE REGULATORS

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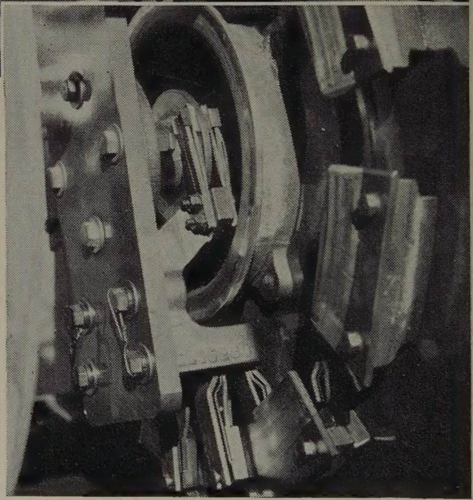

Practically No Wear After 1,240,000 Operations

Pictures above and at right show mechanism and contacts of an Allis-Chalmers power regulator that operated on a west coast utility for 17 years. You can see from these unretouched photos that nearly a million and a quarter operations resulted in practically no wear. This regulator is still in condition to provide many more years of satisfactory service.

You get operating records like this only from Allis-Chalmers. Twenty years of experience designing and building ⅝% step voltage regulators results in rugged construction and proved reliability. Laboratory tests, for example, show that the *Quick-Break* mechanism can withstand five million operations. The 17-year result shown above adds field proof to these laboratory tests.

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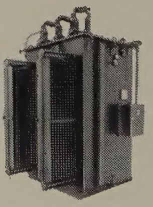
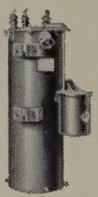
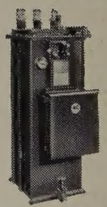


Three-Phase Power Regulator



Single-Phase Distribution Regulator



Single-Phase Power Regulator

ALLIS-CHALMERS

Originators of ⅝% Step Regulation

ELECTRICAL ENGINEERING

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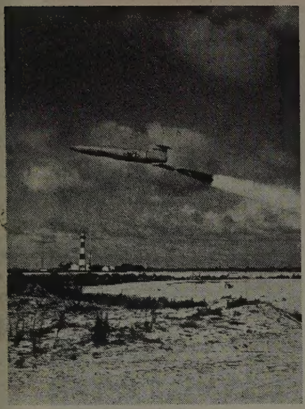

The Cover: Rocket-powered missiles that roar off the launching pad at Cape Canaveral, Fla., are headed out to sea on a bearing of 127° following the path of a polyethylene coaxial cable laid on the ocean floor, as described in "Of Current Interest," pages 383–4.

Message on Unity From the President . . . . Elgin B. Robertson . . . 299
The Engineer and Intellectual Property . . . . R. H. MacCutcheon . . . 301
Ten Founding Fathers of the Electrical Science—I . . . . Bern Dibner . . . 306
The New Kearny Generating Station . . . . M. D. Hooven . . . 308
Effects of Recent Scientific Developments on Electronics Education . . J. D. Ryder . . . 312
40 Years of Electrical Engineering Progress in Tankers . . . . L. M. Goldsmith . . . 316
Development of Good AIEE Public Relations . . . . R. T. Ferris . . . 324
Radio-Relay Remote-Control System for FM Broadcast Stations . . T. R. Humphrey . . . 327
Nuclear Power Plants for Ship Propulsion . . . . F. E. Crever, T. Trocki . . . 331
Line Amplifiers for Community Television Systems . . . . K. A. Simons, Don Kirk, H. J. Arbeiter . . . 337
Principles of Operations Research . . . . J. B. Lathrop . . . 343
Precise Measurement of Repeater Transmission . . . . Thaddeus Slonczewski . . . 346
High-Speed Control by Frequency-Shift Audio Tones . . . . D. C. Pinkerton, L. C. Widmann . . . 350
A UHF Transmitter Employing Klystron Power Amplifiers . . . . W. H. Sayer . . . 354
Transistor Application Fundamentals . . . . R. F. Shea . . . 360

APRIL
1954

TECHNICAL PAPER DIGESTS

The Hungry Horse Project Power Development . . . . F. M. Wilson . . . 305
Trends in Automation—Electrolytic Tinning . . . . P. R. Gravenstreter, R. E. Layton . . . 310
Resonant Dielectric Amplifier Frequency Response . . . . G. W. Penney, E. A. Sack, E. R. Wingrove . . . 311
Compressed Air Circuit Breaker for High Currents . . . . H. H. Rugg, J. E. Schrameck . . . 315
Green's Functions in Evaluating Fields . . . . J. J. Smith . . . 323
Practical Aspects of Brush Stability . . . . W. B. Belt . . . 326
Single-Core Magnetic Amplifier Analysis . . . . Max Frank, Saul Rabotnick, J. R. Walker . . . 336
A Stray Loss Problem in Transformer Tanks . . . . F. J. Vogel, E. J. Adolphson . . . 348
A Transducer Using a Short-Circuit Rotor . . . . V. A. Orlando . . . 349

MISCELLANEOUS SHORT ITEMS: Instrument Measures Electronic Noise and Distortion, 309; Report on Color Transcriptions, 335; Radomes of Sandwich Material, 342; Largest Stator Ever Shipped From U.S. to South America, 345; New Betameter Design for Coating Measurement, 347; Radar Equipment Tests Strength of Radio Signals, 359; Blimp Spots Trouble for Miami, 365

Institute Activities 366
AIEE Fellows Elected, 376; AIEE Personalities, 378; Obituaries, 381; Membership, 382

Of Current Interest 383
New Books, 388

Industrial Notes 18A
New Products, 18A; Trade Literature, 46A

Index to Advertisers 94A

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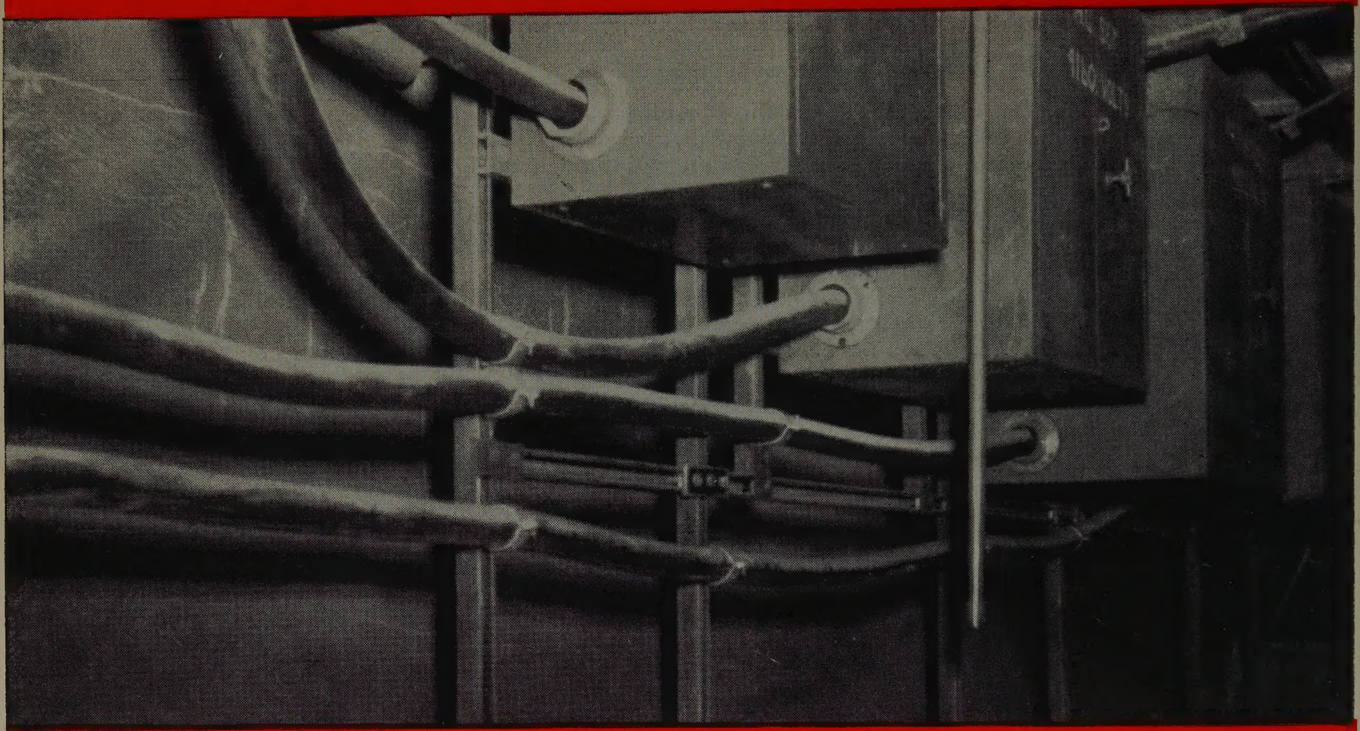

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HIGHLIGHTS........

Message From the President. President Robertson reports in this issue the results of a review of the progress made toward unity as carried out by a special committee appointed by the Board of Directors for that purpose. The committee's report, which was approved by the Board, is presented in full (*pages 299–300*).

The Engineer and Intellectual Property. The engineer in his work as inventor and designer should know something also of the procedure for handling the product of his mind once it has been created, and so a brief statement of the essentials of patent and copyright law has been prepared (*pages 301–04*).

Ten Founding Fathers of the Electrical Science. The first of a series of ten articles to appear serially discusses the contribution of Dr. William Gilbert, author of the first book printed in England on experimental physics and electricity. Gilbert's studies and experimentation in magnetic and electric properties, his concepts of the earth as a great magnet, and the differences he pointed out in magnetic and electrical attraction are described (*pages 306–07*).

Scientific Developments and Electronics Education. Servomechanisms, transistors, transients, these are just a few of the recent scientific developments which the schools are being asked to include in their curricula. How can they be incorporated into an already crowded schedule? It is suggested that since the fundamentals already may be included in other courses, a reorientation of this fundamental teaching may accomplish the job (*pages 312–14*).

Development of Good AIEE Public Relations. A successful program of AIEE public relations should benefit not only the Institute, but should provide the public with a better understanding of what the electrical engineer is contributing to the progress and welfare of the nation. The chairman of the AIEE Committee on Public Relations discusses the group's plans for 1954 (*pages 324–5*).

News Index

Institute Activities.................366

North Eastern District Meeting..............366
Future AIEE Meetings..........................367
Conference on Transistor Circuits...............369
Electronic Components Symposium...........370
Washington Section Student Night...........371
Committee Activities..........................374
AIEE Fellows Elected..........................376
AIEE Personalities............................378
Obituaries......................................381
Membership....................................382

Of Current Interest................383

Radar Station to Track Guided Missiles.......383
Computer Memory Improvement Program....384
Specially Cast Plastic Scintillators............385
Future Meetings of Other Societies...........385
New Books.....................................388

Precise Measurement of Repeater Transmission. The transmission of a carrier repeater section was measured in the laboratory. The high accuracy of the measuring circuit, 0.001 decibel, was obtained by using a rapid switching technique (*pages 346–7*).

Radio-Relay Remote-Control System for FM Broadcast Stations. A New York State network controls two of its transmitters from a remote point. The equipment and its successful operation is described (*pages 327–30*).

Nuclear Power Plants for Ship Propulsion. The eyes of the entire engineering fraternity are on the progress being made in the prototypes of the atomic engines for submarines. A fundamental discussion of these power plants is found in this issue (*pages 331–5*).

Principles of Operations Research. Operations research is a branch of scientific research which is concerned more with understanding an operation than with relations among the numbers describing it. As a complement to the other services aiding management, this method can make substantial contributions to the solution of management problems (*pages 343–5*).

Electrical Engineering Progress in Tankers Over the Past 40 Years. The growth in the use of electricity in the marine field has followed the pattern of land-based installations—from small d-c machines for lighting only to large d-c systems for all services including propulsion, and finally modern relatively high-voltage a-c installations. However, as the first full-scale atomic power plant, now under construction, will be a marine installation this trend will be reversed, at least to some extent (*pages 316–22*).

High-Speed Control by Frequency-Shift Audio Tones. Increased use of microwave equipment by industry and especially by the electrical utilities places unusual demands on audio-tone multiplexing equipment for high-speed control functions. Use of well-proved circuitry obtained through experience gained from design of carrier-current control equipment enables engineers to provide high-reliability tone equipment to industry (*pages 350–3*).

Transistor Application Fundamentals. The basic philosophy of transistor circuits is discussed. A phonograph preamplifier is used as an example to illustrate the differences between tube and transistor circuits (*pages 360–5*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Line Amplifiers for Community Television Systems. Although the first such system was installed in May 1950, the systems now in operation provide television reception to a potential audience of several thousand people. One of the major problems of community system design, the choice of suitable amplifiers for relaying signals along main trunk lines, is investigated (*pages 337–42*).

The New Kearny Generating Station. Two 145,000-kw units have been added increasing the entire station's capacity to 624,000 kw. The two turbine generators and two boilers are arranged with their controls in one central room for greater operating efficiency (*pages 308–09*).

A UHF Transmitter Employing Klystron Power Amplifiers. The mechanical aspects of the high-powered cascade klystron and its use as a broad-band amplifier are discussed, together with other features of the uhf transmitter (*pages 354–9*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

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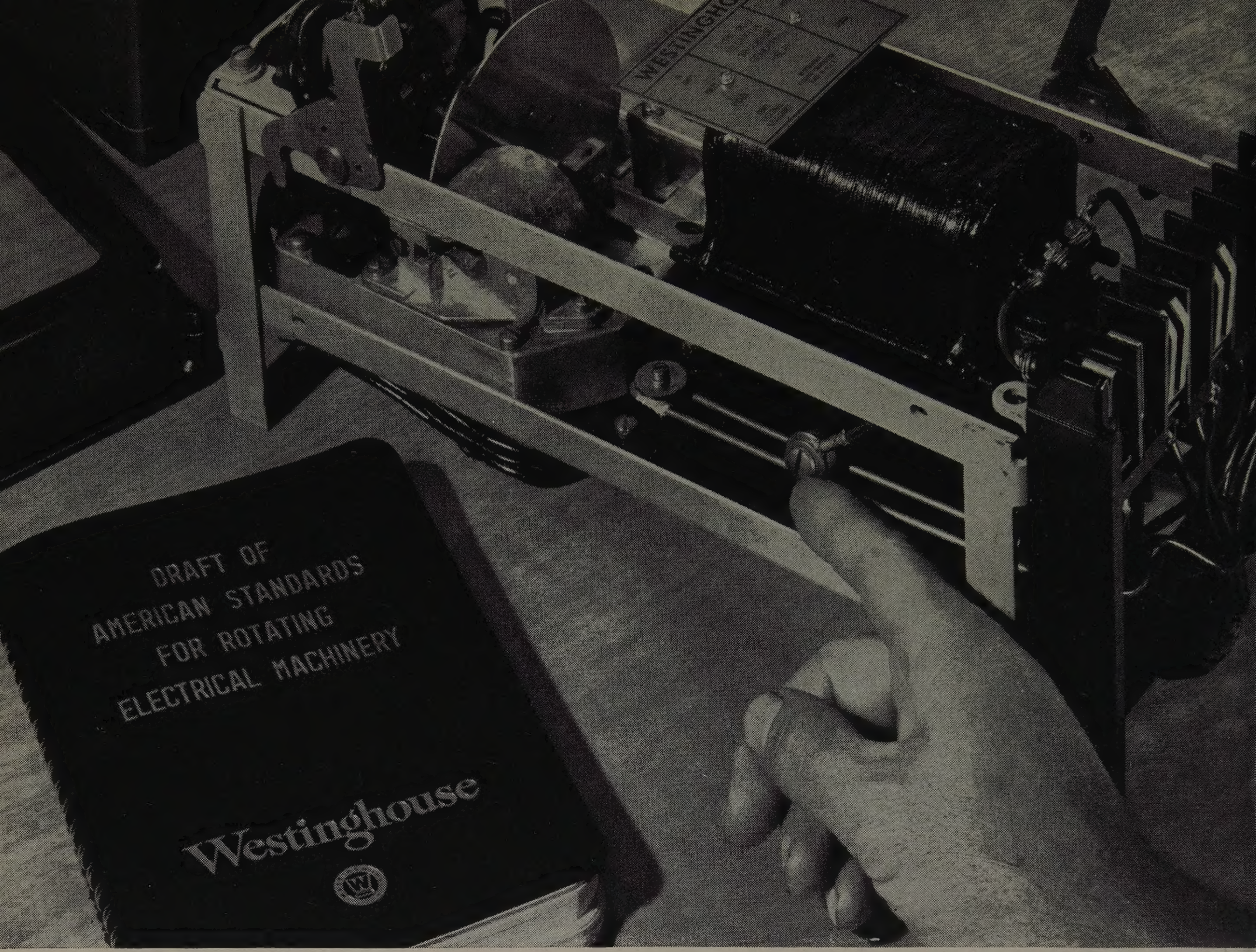

New Westinghouse relay protects generators from negative sequence currents

The filter in the Westinghouse COQ relay is the key to definite protection of generators from negative sequence currents which can cause serious heating damage to rotors. The reactor and resistor elements in this filter permit only the negative sequence component of current to pass on to an induction-disc, overcurrent element. When this current exceeds a safe value for a predetermined time, the relay operates to protect the generator.

New Standard—The American Standards Association has recognized the damaging effects of negative sequence currents by rewriting the Standard covering the ability of a generator to withstand a short circuit at its terminals. This new Standard expresses this ability in terms of how much negative sequence current the generator can withstand and for how long. There is one obvious way to keep a generator from exceeding the limits it was built to meet, as expressed in the ASA Standard. That is, to design a relay that operates on negative sequence current and time. The new Westinghouse COQ relay has been tailor-made for this job.

The relay has a current range of 3-5 amperes which is subdivided by seven taps. Other features include a simple design requiring no internal transformers, a new die-cast damping magnet and a new E element overcurrent electromagnet. Adjustment of the filter element is very easy, requiring only the movement of a slider on the resistance wire.

Out of the Westinghouse relay laboratory in Newark, N. J., has come, through the years, a constant parade of relay "firsts" such as the COQ relay. For the finest relay engineering, the very latest relay developments, look to Westinghouse.

For more information on the COQ relay, write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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Message on Unity From the President

ELGIN B. ROBERTSON
PRESIDENT AIEE

Thinking that a review of the progress made toward unity might be of value, a committee from the Board of Directors was appointed to make this study.* This committee submitted its report to the Board at its meeting on January 21, 1954, and the report is presented in the following for your information. This report was approved by the Board, and the Institute's representatives on Engineers Joint Council were instructed to advise the Council of the seriousness with which we view the need for real unity, and to work toward implementing the recommendations of the committee.

SINCE the Engineers Joint Council (EJC) has modified and adopted the "Report of the Exploratory Group to Consider the Increased Unity of the Engineering Profession" submitted in December 1951, invitations to join the Council were extended to eight of the ten engineering societies, outside of EJC, that participated in the Exploratory Group. The societies receiving invitations were the following:

American Association of Engineers
American Society for Engineering Education
American Society of Heating and Ventilating Engineers
American Water Works Association
Institute of Aeronautical Sciences
Institute of Radio Engineers
National Society of Professional Engineers
The Society of Naval Architects and Marine Engineers

Three of these engineering societies have elected to accept the invitations to join the Council and have been admitted. These societies are

American Society for Engineering Education
American Water Works Association
The Society of Naval Architects and Marine Engineers

Two societies have rejected the invitation and they are

Institute of Radio Engineers
National Society of Professional Engineers

Three of the engineering societies invited to join the Council allowed the time limit of the invitation period, which was December 31, 1953, to expire without accepting the invitation. These societies are the following:

American Association of Engineers
American Society of Heating and Ventilating Engineers
Institute of Aeronautical Sciences

The total membership of EJC is now eight societies and the prospect of increasing this number in the near future is not good. The most likely potential new member societies have allowed their invitations to lapse without acting upon them as indicated in the foregoing and in the future it will be necessary for them to apply for membership.

In view of the record it appears that the EJC as now organized and constituted is not developing into the form of unity organization desired generally by engineers.

Over the past 7 years the AIEE has conducted four separate investigations to determine the wishes of its membership regarding various forms of unity organizations. The results of these investigations have been reported as follows:

1. "Professional Activities Subcommittee Reports for 1946 on Organization of Engineering Profession" (*EE, May '47, pp 496–501*).
2. "1949 Membership Opinion Poll on Institute Policy" (*EE, Mar '50, p 194*).
3. "1950 Membership Opinion Poll on Institute Policy" (*EE, Aug '50, p 669*).
4. Survey of Sections on Proposed Plans *A*, *B*, *C*, and *D* of the Exploratory Group. Reported in a letter by James F. Fairman, April 17, 1951, addressed to the Exploratory Group members and to the AIEE Board of Directors.

The results of each of these surveys favored the general form of organization known as Plan *C* ("Merger Plan") outlined in the "Report of the Exploratory Group t Consider the Increased Unity of the Engineering Profession," December 1950. The most important basi requirements in the preferred form of organization wer the following. It should be based upon individual membership rather than a council of societies; it should b clothed with power to act promptly when required; an it should be adequately financed.

In voting for the changes in the EJC constitution t provide for the expansion of the Council, the AIEE Boar of Directors did not consider the modified EJC to be th desired unity organization. Rather it was looked upo as a possible vehicle through which a suitable organizatio might be developed.

The studies made to determine the wishes of our member have indicated that they do not believe that the Counci type of organization has any chance of serving as a satis factory permanent unity organization and in the past th Board has supported that view. The soundness of thi

---

Elgin B. Robertson is president, Elgin B. Robertson, Inc., Dallas, Tex.

* Committee: Walter J. Barrett (unable to participate in final draft due to inabili to attend the Winter General Meeting), R. F. Danner, L. F. Hickernell, T. M. Linvil F. O. McMillan, chairman.

position is indicated by the following observations on this subject:

1. Thirty years of experience both in the United States and Canada show that the top level federation or council type of organization has been inadequate to meet the requirements of the engineering profession especially in nontechnical activities. Some examples of the experience with these organizations and the changes that have been made in attempting to meet the demands are the following:

    (*a*). The Engineering Council of the National Technical Societies of America was organized in 1917.

    (*b*). The American Engineering Council was formed in 1920 to supersede the Engineering Council of the National Technical Societies of America and was dissolved sometime prior to 1940.

    (*c*). The Engineering Institute of Canada (EIC) was formed following World War I out of what was then the Canadian Society of Civil Engineers. This institute proposed that it should be the National Engineering Institute to which all Canadian engineers of all branches should belong. This objective never has been reached.

    (*d*). The idea of a "Unity" organization in Canada was reborn during World War II largely to prevent engineers from being included within the scope of certain labor legislation that would have had the effect of including them in over-all collective bargaining units. First the "Committee of Fourteen" was organized. This committee was composed of the then presidents of the major professional or technical organizations in Canada. This committee attained its original objective and it was proposed to organize a permanent organization on this basis. The EIC took exception to the organization, contending that it already existed in EIC.

    (*e*). An organization, the "Canadian Council of Professional Engineers and Scientists," was completed in immediate postwar years without the co-operation of EIC. This Council continued until February 28, 1950, when it was disbanded. An engineer who participated in this organization reports it's failure as follows: "Unfortunately the Council 'ran aground' on the twin rocks of: (*a*) insufficient financial support, and (*b*) its impotence in that nothing could be done without reference back to its supporting societies."

    (*f*). Engineers Joint Conference, organized in the U S. in 1941, was composed of the Presidents and Secretaries of the five participating societies.

    (*g*). The EJC evolved from the Engineers Joint Conference in 1945 when the representation from the constituent societies was increased.

    (*h*). In 1949 the EJC invited 16 major engineering societies to participate in an Exploratory Group to consider the unity of the engineering profession.

2. The Council-type organization is less secure than an organization founded upon individual membership because of the ability of an entire society of several thousands of members to withdraw at one time.

3. The financial support of a Council-type organization is less secure than for one founded upon individual membership for the same reasons cited in item 2.

The committee, after reviewing the present status of unity in the engineering profession under EJC as now organized and constituted, feels that progress is not satisfactory. It is the further belief of this committee that there is a critical need for an effective, adequately supported unity organization and that the time rapidly is running out in which the engineering profession can forestall the serious encroachment of unionization unless such an organization is formed.

Institute members through their Sections and in other ways are asking the AIEE to take action that will expedite and implement unified action on the part of the engineering profession. These requests emphasize the importance and urgency of this matter.

The Pittsfield Section has addressed a letter, dated January 4, 1954, to the Board of Directors expressing the concern of their membership about lack of unity and requesting the Board to take action to establish an appropriate unity organization based upon individual membership. This letter also was sent to all Sections in District 1.

One unity plan has been outlined in an article, "A New Unity Plan Proposal," by J. C. Dutton, W. J. Degan, and J. L. Oprisch (*EE, Apr '53, pp 349–51*). This plan is proposed by the General Electric Engineers' Association which includes a large number of AIEE members.

The Denver Section has forwarded a letter to the President and all of the Sections of the Institute in which definite action toward unity is urged.

The Schenectady Section has transmitted a letter to the Board of Directors asking that it take positive, prompt action toward establishing a unity organization.

The AIEE Sections Committee at its meeting on January 19, 1954, unanimously passed the following resolution:

"Resolved, that since it is the policy of the Institute, as affirmed by the Board of Directors' statement of June 15, 1950, to work continually for the unification of the profession and since actions are pending in National and State Legislatures which may restrict the development and unification of the engineering profession, we, the Sections representatives, urge the Board of Directors to vigorously continue efforts to find an acceptable basis for unity of the profession."

This committee recommends that the Board of Directors should insist that EJC immediately take steps toward the development of a unity organization based upon individual membership as we had hoped would be done when the present Council expansion plan was launched in 1951.

To initiate and implement the formation of a unity organization to meet the present needs, the committee recommends that the EJC be asked to appoint a committee instructed to develop a plan for the unification of the engineering profession based upon individual membership, vested with power to act promptly and provided with a sound plan for financing.

The Engineer and Intellectual Property

R. H. MacCUTCHEON
ASSOCIATE MEMBER AIEE

Since the engineer is concerned primarily with the product of his brain, it is important that he know something about the care and handling of intellectual property. It is with the engineer's interest in mind that this condensed statement of the essentials of patent law has been prepared.

THE ENGINEER cannot prosper or progress without selling such an ethereal thing as the output of his brain. Particularly if he is connected with a manufacturing company, the engineer ought to know something about the care and handling of intellectual property, for that is a thing in which he and his employer must deal.

The right to copy the product of the mind of another is affected by the laws of patents, of copyrights, and of trademarks. It is a purpose of this article to explain these laws briefly and in connection with them to discuss a few procedures believed to be desirable in industry today.

PATENTS

AMONG the reasons why an industrial company may seek patents covering its employees' inventions are

1. To protect the expenditure of development costs by permitting suits for infringement.
2. To assure a profit by minimizing competition.
3. To protect against others patenting the same thing, thereby hampering the company's freedom of action.
4. To stimulate inventive employees by offering tangible recognition of the novelty and usefulness of their work.
5. To acquaint employees with patent procedures.
6. For advertising and prestige purposes, to provide proof that the company is progressive.
7. For marketing purposes since the salability of an idea is usually enhanced by patenting it; a prospective buyer wants to know whether an idea is new or old and whether there is any assurance against competition.
8. For trading purposes in a field in which patents are held by competitors, or to serve as a protected investment for a company of limited means which otherwise might be relatively helpless in dealing with promoters or investors.
9. To make possible the collection of royalty income. Sound patent acquisition and patent licensing policies allow a company to place itself in the advantageous position of realizing a relatively worry-free income from another company's manufacturing and sales efforts.

In these confusing days of complex national and international problems, the engineer cannot afford to forget basic economic facts so clear to his predecessors a half century ago. Competition still exists, still carries with it the risks of loss and of possible ruin. Few reasons exist for not employing every legal advantage to meet these risks. One such advantage is the exclusive position provided by the limited patent monopoly specifically authorized by the government.

In the United States the patent grant may be thought of as a contract. In exchange for the inventor's disclosure, the government grants to him, or to anyone he may designate, the right to exclude others from making, or using, or selling things or processes embodying the invention. This monopoly is limited to 17 years, but even such a limited reward has been found to serve as a powerful impetus to research, invention, and development. In China, it has been said, the lack of patent laws contributes to the lack of technical progress, while in Japan similarly constituted people are stimulated by patent laws which enourage them to give to civilization the fruits of their creative thinking. In America, the Patent Office was set up during the term of Washington, and it provided a system which, in the words of Lincoln, adds the fuel of interest to the fires of genius.

The engineer often asks: "Just what is a patentable invention?" There are only three requirements; see Table I.

Happily, the engineer can disregard requirements 2 and 3; he can leave these details to patent attorneys, government patent examiners, and courts. But he ought to know something about requirement 1, the novelty requirement relating to seasonable application for patent. Otherwise he may fail to see his attorney until too late.

While only the first inventor may receive a patent, proof of prior invention is limited to the United States unless invention abroad has taken the readily provable form of a publication or patent. Further, while only the first inventor may receive a patent, even he is not entitled to it if he waits too long to apply while telling others about the idea through publication, sale, or use, or while someone else enters the field. The applicable statute provides that prior to the time of invention by the applicant the subject matter of the invention must not have been known by others in this country, or patented or published in any country, and, moreover, at any date more than one year before date of filing in the U.S. Patent Office, the invention must not have

Table I. Requirements for Patentability

1. Novelty	2. Class	3. Invention
(*a*) Prior to invention by *A*, not known in U.S. or patented or published in any country (*b*) More than one year before filing for patent, not in public use or on sale in U.S. or patented or published in any country	(*a*) Machine (*b*) Article (*c*) Composition of matter (*d*) Process for using or treating *a*, *b*, or *c*	$I=\frac{E}{R}$

Full text of a special article recommended for publication by the AIEE Committee on Award of Institute Prizes. It was a 1953 Prize Paper, AIEE Cleveland Section.

R. H. MacCutcheon is a patent attorney in Cleveland Ohio.

been in public use or on sale in the United States, or patented or published in any country.

Regarding the second and third requirements, which may be of interest even though not perspicuously germane to the duties of the engineer, statutory classes of patentable subject matter include only machines, articles, compositions of matter, certain kinds of processes, and certain kinds of growing plants. They do not include mere mental theories or methods of advertising.

Engineers, and lawyers as well, have the most difficulty with the matter of invention. Some decided cases say that to constitute invention the subject matter must display more ingenuity than the work of a mechanic "ordinarily skilled in the art"; that a patent cannot be obtained on every shadow of a shade of an idea. Yet most issued patents are directed toward mere improvements rather than toward products or processes which are wholly new, and the Patent Office and courts realize that the standard of invention must be kept low enough to encourage the translation of ideas into useful products. In one recent Supreme Court case the mere substitution of metal cladding for cardboard to make a flashlight battery cell leakproof was found to involve patentable invention, while in another the super market cashier's sliding grocery rack was held to lack invention. These and other decided cases can be compared and it can be concluded that the boundary of "invention" is tenuous and difficult for the layman to follow, or electrical men can resort to their formulas and say that if $E=IR$, then $I=E/R$, and invention must be equal to some sort of Excellence (of the idea) divided by Resistance (presumably in the mind of the person approached, be he patent attorney, patent examiner, judge; or juryman).

In industry today, seeking to define patentable invention is probably not a very useful occupation. It is better to take particular developments one by one as they come along, and to determine of each whether it is of sufficient importance to justify the expense of an inquiry conducted by engineer and attorney, and possibly involving the government acting through its patent examiners or even its courts, all to ascertain whether patentability in fact exists.

Terms habitual in the patent jargon may sound weird to the engineer, but usually their derivation is fairly straightforward. When an inventor first thinks of an idea he "conceives" it, and this mental step is known as "conception." But the uncorroborated word of an inventor as to when a certain thing passed through his mind will not be accepted in evidence. Therefore, it is customary to reduce such an idea to writing, with the writing "witnessed" at the earliest possible moment. Such a writing, or drawing, or both, discloses the invention and therefore is known as the "disclosure." In actuality a disclosure could be oral, but it is not then readily provable, and because there might later be an "interference" with another, it is best to have the disclosure on paper and signed and dated by the inventor and witnessed and dated by two other people who understand the invention. Such a step is not a prerequisite to filing a patent application, which itself reduces an idea to writing, but as a practical matter is usually to be preferred in order to have the earliest possible provable date. It may be necessary to prove also, as by witnessed test results or similar material, diligence in trying to complete, or in completing, the invention before the filing of the patent application. The invention is complete when it is "reduced to practice" as by being incorporated in a structure which works, adequately and under something like actual field conditions.

It follows that any company wishing to rely upon inventions made by its employees should require that each new drawing or sketch or description of a possibly inventive idea immediately be signed and dated and properly witnessed and that the same treatment be afforded to written evidence of tests and of first successful operation.

Whenever a disclosure is submitted to a patent attorney for his study, he can determine to some extent whether a patent seems possible from a legal standpoint. To this end he will decide whether the idea falls within one of the statutory classes of patentable subject matter, and he will consider the questions of novelty and invention as by comparing with prior publications and patents from which it usually can be determined whether a patent can be obtained at all, and, if it can, whether the possible patent would have a scope broad enough to justify the cost of its acquisition or be so narrowly limited that anyone could use the spirit of the invention without danger of infringement.

Certainly if the inventor's employer is paying the costs, the latter ought to be interested in whether a patent should be sought from an economic standpoint. Yet, often the employer is not consulted. All too often determination of whether a particular invention warrants the expense of a patent application is left solely to inventor and patent attorney. Such a method lacks objectivity. An inventor is usually desirous of having a patent issued in his own name; an attorney is usually anxious to please any representative of his client. Irrespective of the complexity of an invention, the decision of whether to file a patent application thereon should be based on economic grounds, and preferably should be made by management or management-appointed representatives in addition to the inventor and attorney. Some companies use a standing committee for invention review with representation not only from engineering but from sales as well, since often an invention can be classified as an engineering achievement but a commercial failure. If commercial success cannot be ascertained when legal requirements dictate that a patent application be filed immediately, if at all, such a committee may consider the cost of filing on the basis of calculated risk of success. Thus, the cost of ten patents on presently unused developments may be determined to be justified if it seems probable that an undetermined one out of the ten will be used, and that it then will be desirable to prevent others from using the successful invention without having to pay for development of either the success or the failures inherent in the general program of research.

If management, the engineer, and the attorney finally are satisfied that a patent is economically desirable and probably can be obtained, the attorney prepares the patent application in its two principal parts:

1. The Specification, including a description (and usually a drawing), indicating one or more ways of carrying out the invention.

2. A Claim or Set of Claims, to define the boundaries of the monopoly sought to be acquired.

Various statutory requirements dictate that the patent application shall be full, clear, and concise. Therefore, the attorney must have a clear knowledge of the invention and of the field of endeavor to which it relates, and he will remember that his task well may be to prepare a document capable of impressing not only a technically schooled Patent Office examiner, but a nontechnically minded judge or jury with the thought that an invention has been made, and that society is indebted to the inventor for his innovation.

The claim or claims, with which every patent application must conclude, provide a logical definition of that which applicant considers he has originated and to which he believes himself or his assignee entitled to a limited exclusive patent right. If the claims are too broad they will not be allowed. If the claims are too narrow they will not prevent others from using the actual invention. Usually there should be both the broadest possible claims, to cover all combinations which might be attempted by others, and a few narrow claims for avoiding prior art, the relevance of which might not be discovered until many years later, possibly in a suit for patent infringement.

The patent application, an oath (a formalized affidavit as to inventorship), and a check for the initial fee ($30 for the shorter application), and possibly papers of assignment of ownership as to the employer and papers appointing a particular attorney to act in the case, are sent to the U.S. Patent Office; when received there the filing is complete.

In the Patent Office, the application is assigned to an examiner who specializes in the particular field to which it pertains. The examiner reviews the application and usually compares the claims with existing patents to determine if they are patentable. He may reject some or all of the claims, communicating his findings to the attorney who then has 6 months to answer by either canceling, amending, or arguing rejected claims, depending on how he elects to prosecute the application toward allowance. The easiest road might appear to lie in acquiescing in the examiner's first holding by canceling broader claims, but the easy road is not always the best and the value of an issued patent depends as much on intelligent prosecution after filing as on proper preparation of the original papers.

If, during prosecution, the examiner holds that even though the exact thing claimed is not old it represents no invention, the attorney may wish to argue that in view of the difficulties and intricacies of the particular industry the inventor made a real contribution, opened a long closed door leading to progress. If no agreement is reached between examiner and attorney, a review may be had before tribunals in the Patent Office and in the courts.

If final agreement is reached, the case is "allowed" by the examiner. The attorney then sees that the final fee is paid (an additional $30, or more) and subsequently a patent issues on the application. When he has his patent, the patentee can license others under it, or can sue others for infringement, for he has the exclusive right of production, of use, and of sale. Thus a patent permits the recoupment of development costs with little danger of others reaping where they have not sown.

In the United States an injunction against infringement can be obtained at any time, but money damages cannot be collected in a law suit for infringement unless the patent owner can show both damage to himself and, to the other party, notice of the patent. The familiar designation "Pat. Pending" has no legal significance in this connection. It merely means that an application has been made for a patent which may or may not issue, and which may or may not cover goods so marked if and when it does issue.

Sufficient notice of an actual patent may be made by marking, with the patent number, all goods sold which incorporate the invention. This is "constructive notice," assumed by law sufficient to notify the world, but, in a company of any size, legally sufficient patent marking requires awkward and expensive procedures.

As an alternative to such notice by marking, the legally required notice may be actual notice given by letter, and this type of notification is quite usual. Generally it is wise to have the unpleasant news of patent infringement sent over the signature of the patent attorney, for experience has indicated that otherwise pleasant commercial relations are not likely to be upset when an attorney writes such a letter. He can phrase it in a friendly manner without indicating that his client even complains of the infringement, saying, for instance, that the attorney's attention has been called to such and such a device which seems to infringe the client's patent and it would be appreciated if the recipient would look into the matter.

No discourse intended for engineers and on patent procedures would be complete without mention of the subject of avoiding infringement of the patents of others. Whenever an engineer contemplates changing his company's product, or designing an entirely new product, he ought to give thought to the patent situation, to the possibility of the existence of adversely held unexpired patents. Otherwise it later may prove necessary to pay royalties, quite probably to a competitor; or the patent owner may not even accept royalties and may insist instead on the expensive and embarassing removal from customers' premises of infringing devices already sold and installed.

In this article, it is impossible to cover adequately many other subjects of interest and of importance to the engineer in regard to patents. However, these might include:

1. Suggested rules for the engineer-author if he does not want to jeopardize his employer's patent, fair-trade, or antitrust law position.

2. Receiving ideas from outsiders. The engineer ought to guard against promises to treat the outsider fairly, to treat his ideas as confidential, and against commenting favorably on his ideas.

3. Employees' rights to their inventions. This is mainly a matter of contract, express or implied.

4. Desirability of filing or not filing patent applications on shop tools and processes. If it cannot be determined how other shops work, a patent may not be of much value.

5. Liability for infringement as between buyer and seller of goods. In this case an express contract usually will control; if there is none the seller is responsible as between the two. "Caveat Emptor" does not apply here.

6. Patent licensing policy and the antitrust laws.

7. Patent clauses in government contracts. This has two parts: responsibility for infringement, and respective rights in inventions made.

8. The peculiar law applying to joint owners of a patent. Either may license without sharing the proceeds with the other.

9. Contributory infringement (by one making only part of a patented combination). Those familiar with the Supreme Court cases should remember that the Patent Act of 1952 (effective January 1, 1953) probably changes some of the court made law on this subject.

10. Technical aid from existing patents. Time spent in experimentation may be devoted to more useful endeavors by he who is willing to determine how others did it.

11. Design patents relating to ornamental designs as of jewelry, wallpaper, wearing apparel, radio cabinets, or even locomotives. A design patent may be for $3^1/_2$, 7, or 14 years, depending on the fee paid, as is shown in Table II which compares the length of term and renewal privilege for mechanical patents, design patents, copyrights, and trade-marks.

Table II. Terms and Renewal Privileges

Item	Where	Term (Years)	Renew?
Patent	Patent Office	17	No
Design patent	Patent Office	$3^1/_2$	No
		7	No
		14	No
Copyright	Library of Congress	28	Once
Trade-mark	Patent Office	20	Forever

COPYRIGHTS

A COPYRIGHT is a right to copy, and wherever it is an exclusive right, to prevent others from copying.

An exclusive copy "right" belongs to authors, artists, and composers, and to those to whom they assign, but the right as it exists at common law is lost as soon as the book, article, advertisement, sermon, play, map, picture, movie, music, or whatever is published. No actual loss occurs if there is strict compliance with the copyright statute requiring the marking of all published copies with the requisite notice of copyright and the sending of two of these copies along with the required fee and application for registration to the Copyright Office, a part of the Library of Congress.

Unlike the examination procedure to which patent and trade-mark applications are subjected, copyright applications are merely deposited, the validity and scope of the copyright registrant's rights not being passed upon unless by a court in a subsequent law suit. The registration is good for 28 years and renewable for one additional 28-year period.

The possible consequences of infringement of the copyrights of others should be borne in mind by the engineer. While advertising people usually will be found trained to avoid copyright hazards, a company may be involved in a suit for copyright infringement by other classes of employees; by those arranging a conference skit, by those responsible for broadcasting recorded music to plant workers, by a sales engineer preparing a novel Yuletide greeting.

TRADE-MARKS AND TRADE NAMES

THE American buyer purchases according to established brands and from established firms to a great extent, but he seldom realizes that the use of trade-marks as indicative of sources of goods originated in very ancient civilizations. Unlike the patent law which is entirely statutory, the law of trade-marks has a common law base. Under certain circumstances of public acceptance and prior exclusive and proper use, the owner of a trade-mark or name is entitled to continued exclusive use regardless of whether the mark or name is registered with the Patent Office. However, such registration allows the owner to use the Federal courts and, of more importance, the registration serves as *prima facie* evidence of originality (for the government has made a search) and as *prima facie* proof that the mark is valid and is owned by the registrant.

Under the trade-mark law of 1946 (effective 1947) registration is, with long prior use, now permitted of names which are primarily geographical or descriptive, but this is not to say that choice of such a name is as good as that of one neither geographical nor descriptive in connotation.

Registration under the 1946 law constitutes constructive notice. Actual notice need not be given and, since innocent intent is no defense to a suit for infringement, it follows that anyone adopting a new mark or trade name should have the Patent Office Register searched to see if there would be any infringement of a registered mark or name.

A trade-mark registration, if kept alive by filing a new affidavit of use in 6 years, is good for 20 years, and may be renewed for additional periods of 20 years each.

Trade-marks and names generally are considered as applied to goods. Service marks and names relate to services, such as laundering, insurance, financial, engineering, or transportation services. Service marks and names are as registrable as trade-marks and names, and even the sequence of tones used in the National Broadcasting Company chimes has been held registrable as a service mark.

Hazards in trade-mark practices are presented by allowing two companies to use the same mark, by attempting to use a mark from which there may be implied an attempt to deceive; but from the standpoint of fulfilling the purposes of this article it is most important to point out the hazard of trade-mark misuse amounting to abandonment. Anyone can profit from the sad experiences of others, of the Otis Elevator Company which allowed "escalator" to become what the lawyers call generic, of those who allowed cellophane, aspirin, linoleum, and cola to become regarded by the public as materials rather than each as an indication of goods from a particular source. It is suggested that the engineer-author find out just what words constitute his own company's registered trade-marks. Then when he uses any such word he should set it apart, as by putting it in caps or quotes; he should mark it as with an R in a circle, or with a footnote indicating registration and ownership; and he should strive to use the word as an adjective rather than as a noun. In others words, the engineer-author should not contribute to the possibility of cancellation of the mark from the Register on the ground that its owners have allowed it to become a part of the language and thus a common inheritance.

The Hungry Horse Project Power Development

F. M. WILSON
MEMBER AIEE

LOCATED ON THE South Fork of the Flathead River in northwestern Montana are the Hungry Horse Dam and Power Plant which constitute a key unit in a comprehensive program for multiple-purpose development of the vast resources of the Columbia River and its tributaries.

The variable-thickness arch-type concrete dam has a volume of 2,934,000 cubic yards and a height above the limestone bedrock of 564 feet. Among concrete dams in the United States it ranks fourth in volume and third in height. Formed by the dam is a reservoir with a surface area of 22,500 acres and a capacity of 3,500,000 acre-feet. An interesting feature of the project is the glory-hole inclined-shaft-type spillway which has a capacity at the maximum reservoir elevation of approximately 50,000 cubic feet per second. Three 96-inch-diameter outlet pipes controlled by hollow-jet valves provide for regulation of reservoir outflow during normal operation.

To obtain the maximum prime power and the maximum flood control benefits, the Hungry Horse Power Plant with an installed capacity of 285,000 kw will be operated at high capacity during the fall and winter months when the power is most needed and when the water releases can be used to best advantage for generation downstream. In the spring and summer when flows in the Columbia River and its tributaries are at a maximum and power generation at the downstream plants is at a peak, water will be stored at Hungry Horse and generation there will be at a minimum. It is estimated that in addition to the 208,000 kw of prime power made available at Hungry Horse the plan of operation will increase by 355,000 kw the prime power capacities of existing downstream plants. Estimates indicate that river regulation at this plant will increase ultimately by almost 500,000 kw the prime power capacities of other plants under construction or planned to be built in the future as part of the vast Columbia River system.

The powerhouse located at the toe of the dam has a steel superstructure with reinforced concrete walls except for the control bay which is reinforced concrete construction throughout. This type of construction permitted erection of the superstructure steel during the winter months when it was too cold for placement of concrete and allowed much earlier installation of the overhead powerhouse cranes. This in turn permitted earlier installation of the turbines and other equipment.

Each of the four vertical-shaft Francis-type turbines has a speed of 180 rpm and a capacity of 105,000 hp at full gate opening under a net effective head of 400 feet. The full gate discharge at this head is approximately 2,800 cubic feet per second.

The generators are each rated 75,000 kva, 0.95 power factor, 13,800 volts, 3 phase, 60 cycles. System stability considerations required special characteristics to be specified for the generators. Liberal design of the generators gave characteristics considerably better than the minimum specified. Tests indicated the direct-axis rated-current transient reactance to be about 18.6 per cent and the short-circuit ratio to be approximately 2.36. A line-charging capacity curve obtained from test results when extrapolated to zero excitation showed a generator line-charging capacity of approximately 159,000 kva at rated voltage.

Automatic voltage regulation is provided by a rotating-amplifier-type exciter which is inserted in the main exciter field circuit in series with the field rheostat. Voltage regulator operation during overspeed was tested on each machine by suddenly rejecting 110-per-cent rated load at rated power factor. The units attained overspeeds of about 25 per cent following the load rejections and the regulators maintained the generator voltage within approximately 110 per cent of normal under these conditions.

Controls for the generating units are located in the main control room and at the actuators and unit control boards in the governor gallery. Starting procedures require that the governor gallery operator bring the unit up to approximately synchronous speed after first starting the unit auxiliaries. The operator in the main control room then takes over and brings the generator up to voltage and puts the voltage regulator in service, after which he synchronizes the unit with the system and adjusts the load and voltage level as required. Both the control room operator and the governor gallery operator can initiate closure of the wicket gates to shut down a unit. The penstock gates may be closed in an emergency by operation of switches on the main control board and on the unit control board.

Each generator, together with the isolated-phase bus connections to the air circuit breaker, is protected by differential relays. Operation of these relays initiates opening of the generator air circuit breaker, opening of the exciter field circuit breaker, discharge of carbon dioxide into the generator housing, shut-down of the unit by energizing the shut-down solenoid to close the wicket gates, and operation of the unit annunciator to sound an alarm. The main power transformers are protected by differential relays, the operation of which initiates opening of the appropriate high- and low-voltage circuit breakers and causes the associated annunciator system to sound an alarm. In addition, the high-voltage windings of these transformers are protected further by the ground relays for the transmission lines. Seven annunciator systems energized by the 125-volt d-c supply are provided for indication and alarm in case of overloads, failure of equipment, or other troubles.

Digest of paper **54-151**, "The Hungry Horse Project Power Development," recommended by the AIEE Committee on Power Generation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

F. M. Wilson is with the U. S. Bureau of Reclamation, Denver, Colo.

TEN FOUNDING FATHERS OF THE ELECTRICAL SCIENCE

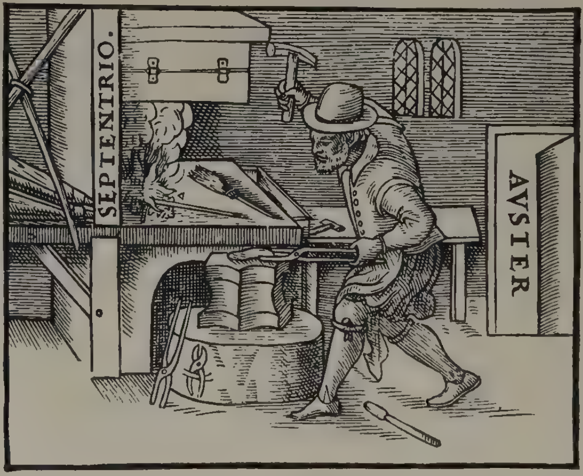
I. WILLIAM GILBERT

on magnets and on electrics

BERN DIBNER
FELLOW AIEE

This is the first of a series of short biographical sketches of ten founding fathers of the electrical science to appear serially in ELECTRICAL ENGINEERING. The selection is arbitrary and other men of equal or possibly greater competence necessarily must be omitted. The series should prove of particular interest to members and students, providing a better understanding of the founders of some of the fundamental electrical principles and units used in daily work. Dr. William Gilbert, royal physician and author of the first treatise on electricity, demonstrated almost all the properties of the magnet, identified the earth as a great magnet, and taught the distinction between electrical and magnetic attraction.

DR. WILLIAM GILBERT of Colchester, England, is claimed by both the electrical scientists and experimental scientists as a "first." He was a product of the era of greatest expansion in England's history—the reign of Elizabeth I—when the frontiers of the physical world and its social institutions were being extended as never before.



From Gilbert's "De Magnete," 1600

Forming a magnet by beating a hot iron bar in the north (septentrio) and south (auster) direction

Gilbert's outstanding contribution is his book "De Magnete," published in London in 1600. In this slender folio Gilbert set down the results of nearly a score of years of intensive experimentation with all the bodies having magnetic and electrical properties known in his day. For the meagerness in number of these substances showing magnetic and electric powers of attraction, Gilbert provided a varied and ingenious series of experiments to determine just what these properties were. By actually performing each experiment himself and describing it in full detail in his book, Gilbert established a pattern of methodical experimental investigation, the first in England, that helped usher in the scientific revolution. We owe to Gilbert the concept that the earth itself is a magnetic body like the loadstone then used in making the mariner's compass. His careful and oft-repeated experiments swept away much of the accumulated mysticism and misinformation that had gathered around this stone with its unusual attractive properties.

William Gilbert was trained in medicine at Cambridge and rose in his profession to become physician to two monarchs (Elizabeth and James I). Living at a time of wide discovery and exploration, his curiosity was attracted by the properties of the loadstone. The reports of the explorers of the variations of the compass in different positions on the earth's surface, the phenomenon of dip, and the retention of the magnetic properties of the loadstone even when broken into smaller parts, caused him to try to determine just what the exact behavior of these elements was.

In the field of electricity, Gilbert's study was the first forward step since the time of Thales (600 B.C.). By adding a chapter on electricity to the other five chapters on the magnet, Gilbert stimulated electrical investigation in the minds of the scientifically curious wherever his book was read. The Latin text of his book made its contents readily understood on the Continent as well as in England; it was reissued on the Continent in 1628 and 1633.

Up to Gilbert's time one electrical fact had been generally accepted, that amber and jet (diamond was added by Fracastoro in 1546), when rubbed, attracted light bodies. Pursuing the phenomena of attraction, Gilbert determined experimentally that a wide variety of material had electrical properties. He devised a pivoted metallic needle (a crude electroscope), and found that not only amber

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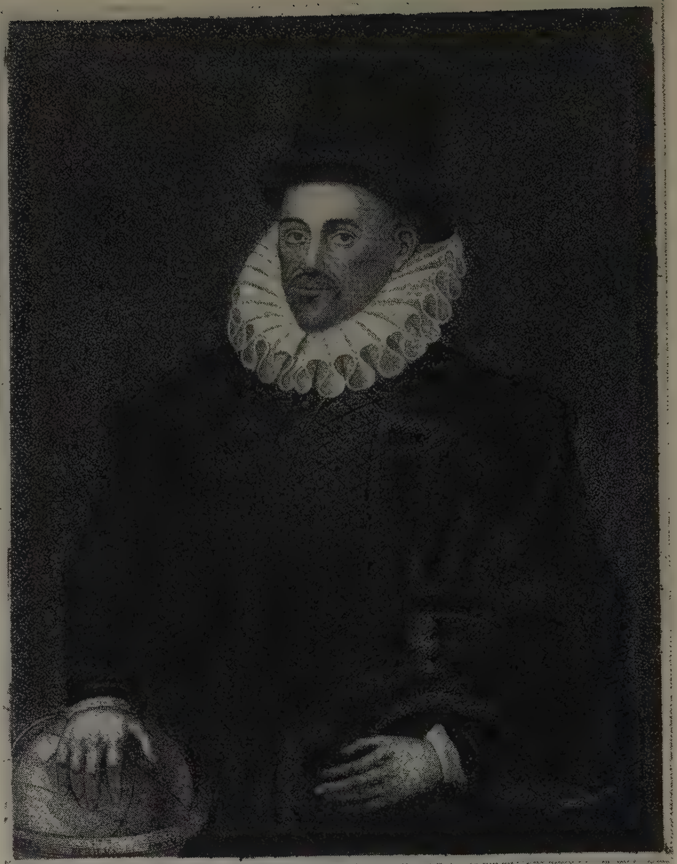
and jet, but more than a dozen other substances acquired electric properties when rubbed; these he termed "electrics." Those substances which could not be made to acquire the attractive power he called "anelectrics." He found glass, sulphur, wax, crystals, and a dozen gems, real and artificial, to have electric attractive power when rubbed. Anelectrics included wood, bone, metals, and even the loadstone. He also found that everything solid or things subject to our senses could be attracted by rubbed electrics. In differentiating between magnetic and electric attractions he observed, "a loadstone appeals to magneticks only, towards electricks all things move. A loadstone raises great weight, so that if there is a loadstone weighing two ounces and strong, it attracts half an ounce or a whole ounce. An electrick substance only attracts very small weights; as, for instance, a piece of amber of three ounces weight, when rubbed, scarce raises a fourth part of a grain of barley. But this attraction of amber and of electrical substances must be further investigated."

The results of Gilbert's experimentation with electrics resulted in more than a score of discoveries never previously recorded. Of these discoveries, the most important half-dozen are the general classification of electrics and non-electrics; the observations that moisture and dampness hinder electrification; the generalization that electrified bodies attract every kind of substance including metals, liquids, and even smoke; the invention of a pivoted metallic electroscope; the observation that the electric, not the intervening air, holds the attractive power; and the observation that heating and roasting electrics tends to dispel the attractive power. In contrasting magnetic and electric attraction Gilbert noted that the former penetrated flame, but that the latter did not. He also noted that electric action could be screened by interposing a film of paper, fabric, or metal, but that magnetic attraction would penetrate thick slabs of almost any material except iron. Gilbert was the first to recognize that water or moisture placed on a rubbed electric destroyed its virtue but that oil "which is light and pure does not hinder it." He also observed that whereas nearly all bodies may be made responsive to electrical attraction, only those containing iron would respond magnetically. Simple as these discoveries were, they still were the first advances in electrical knowledge in 2,000 years.

Not all of Gilbert's magnetic and electrical work is described in his "De Magnete" for, in a book by Thomas Blundeville, published in 1602, there are described other of his nautical magnetical instruments. Further, in a second book by Gilbert, published after his death, he states among other astronomic and meteorologic conjectures that the reason the moon always presents the same face to the earth is that both earth and moon are magnets.

At his death in the plague in London in 1603 he was one of the 30,000 Londoners to be carried away. As a former president of the Royal College of Physicians he willed all his instruments, loadstones, books, and manuscripts to this body. These all were lost in the great fire of London in 1666. His book, a classic in experimental science, is practically all that remains of his many contributions. His patient experimentation (upon which he spent his entire fortune) in which loadstones, iron wires, floating corks, and magnetic needles were examined, was scorned by his prominent contemporary, the learned Francis Bacon. He wrote: "Gilbert hath attempted a general system on the magnet, endeavoring to build a ship out of materials not sufficient to make rowing pins of a boat" and "As the alchemists made a philosophy out of a few experiments of the furnace, Gilbert, our countryman, hath made a philosophy out of the loadstone." Still it brought to an intellectually curious world some simple truths of magnetic and electrical behavior. So positive was Gilbert of the importance of his contributions that he indicated them by the use of asterisks in the margins of his work. We count 21 major discoveries and 178 minor ones, so classified. Similarly, he did not hesitate calling his contributions a "new physiology." Time has proved him both right and modest. He had changed the mystic, impoverished knowledge of "magnetics" and "electrics" of his day into a proved body of experimental data. Gilbert, one of the first among moderns who resorted to experimenting to learn from nature's practices, in his book pleaded constantly that the reader should convince himself by repeating the experiments described. His contribution, therefore, not only is the first book devoted to experimental magnetism or electricity, but is also the first book printed in England on experimental physics.



Harding del Clamp sc

D^r. WILL^m. GILBERT,
Phyſician to Q^n. Elizabeth.
From an Original Picture in the Bodleian Library Oxford.
Pub. 1 May 1796 by S & E Harding Pall Mall.

The New Kearny Generating Station

M. D. HOOVEN
FELLOW AIEE

This new installation consisting of two 145,000-kw units was designed to achieve a plant which would be straightforward and simply arranged with central controls to reduce operating effort. The addition of these units increases the Kearny generating station's capacity to 624,000 kw.

A NEW installation of 145,000-kw units has been completed at the new Kearny Generating Station of the Public Service Electric and Gas Company. Adjacent to the original plant which was placed in operation in 1925 and 1926, the new station consists essentially of two turbine-generators and two boilers arranged in the unit system with their controls in one central room, see Fig. 1. The turbines operate at 2,350 pounds per square inch gauge, 1,100 F at throttle and 1,050 F reheat temperature, each driving a main and auxiliary generator in tandem at 3,600 rpm. Each main generator is rated at 161,765 kva, each auxiliary at 12,500 kva. The main generators are rated at 30 pounds hydrogen, 0.85 power factor, 0.80 short-circuit ratio. Double wound, the two windings are connected solidly at the machine terminals; the voltage is 20,000.

Each auxiliary generator is backed up by a 9,000-kva transformer in providing supply for the 4,160-volt auxiliary system. Two busses serve the auxiliaries of each unit. Automatic throw-over from auxiliary generator to auxiliary transformer is provided. An undervoltage relay connected to potential transformers on the auxiliary generator leads initates the transfer.

A motor-driven exciter set serves each unit; a motor, main generator exciter, auxiliary generator exciter, and flywheel constituting one set. There are three such exciter sets; the main generator exciters are controlled by amplidyne voltage regulators, the auxiliary generator exciters by rheostatic-type regulators. The spare exciter set can be placed in service only by a dead change-over.

The 440- and 220-volt auxiliaries are supplied by load centers with dry-type transformers. Station lighting is variously fed so that lights are available under almost any conceivable condition.

Totally enclosed motors are used outdoors and in unfavorable indoor locations. All motors start across the line. Normally, motors above 350 hp are supplied at 4,160 volts, those between 10 and 350 hp at 440 volts, and those below 10 hp at 220 volts.

Fig. 3 is a simplified 1-line diagram which shows the auxiliary connections and the electrical connections to the Kearny switchyard. The generator leads are in stovepipe bus to the 132-kv transformer area just outside the station wall, see foregound of Fig. 2. The 20-kv bus work in this area consists of 5- by 5-inch ventilated square tubular copper with connections helium-arc welded, an installation innovation which proved to be quite satisfactory.

Two 100,000-kva forced-oil forced-air 3-phase trans-

M. D. Hooven is with the Public Service Electric and Gas Company, Newark, N. J.

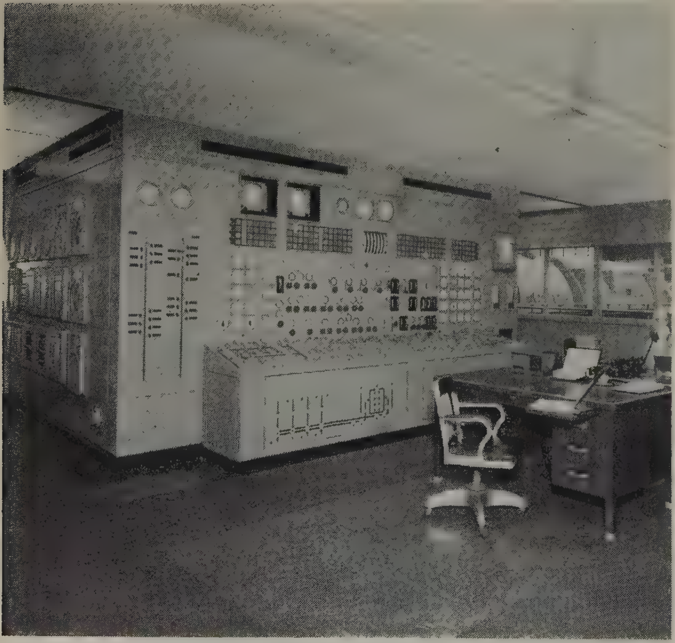


Fig. 1. Control room showing the controls for no. 7 unit

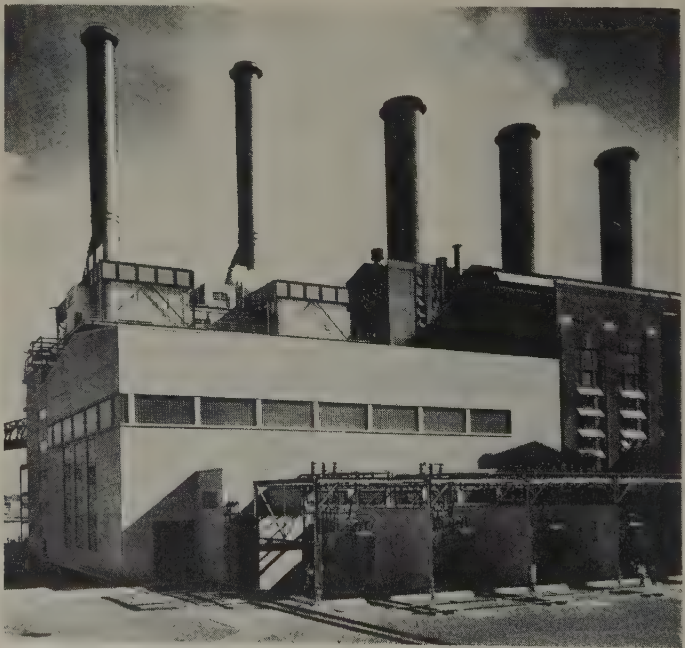


Fig. 2. Turbine room and main transformers of new station

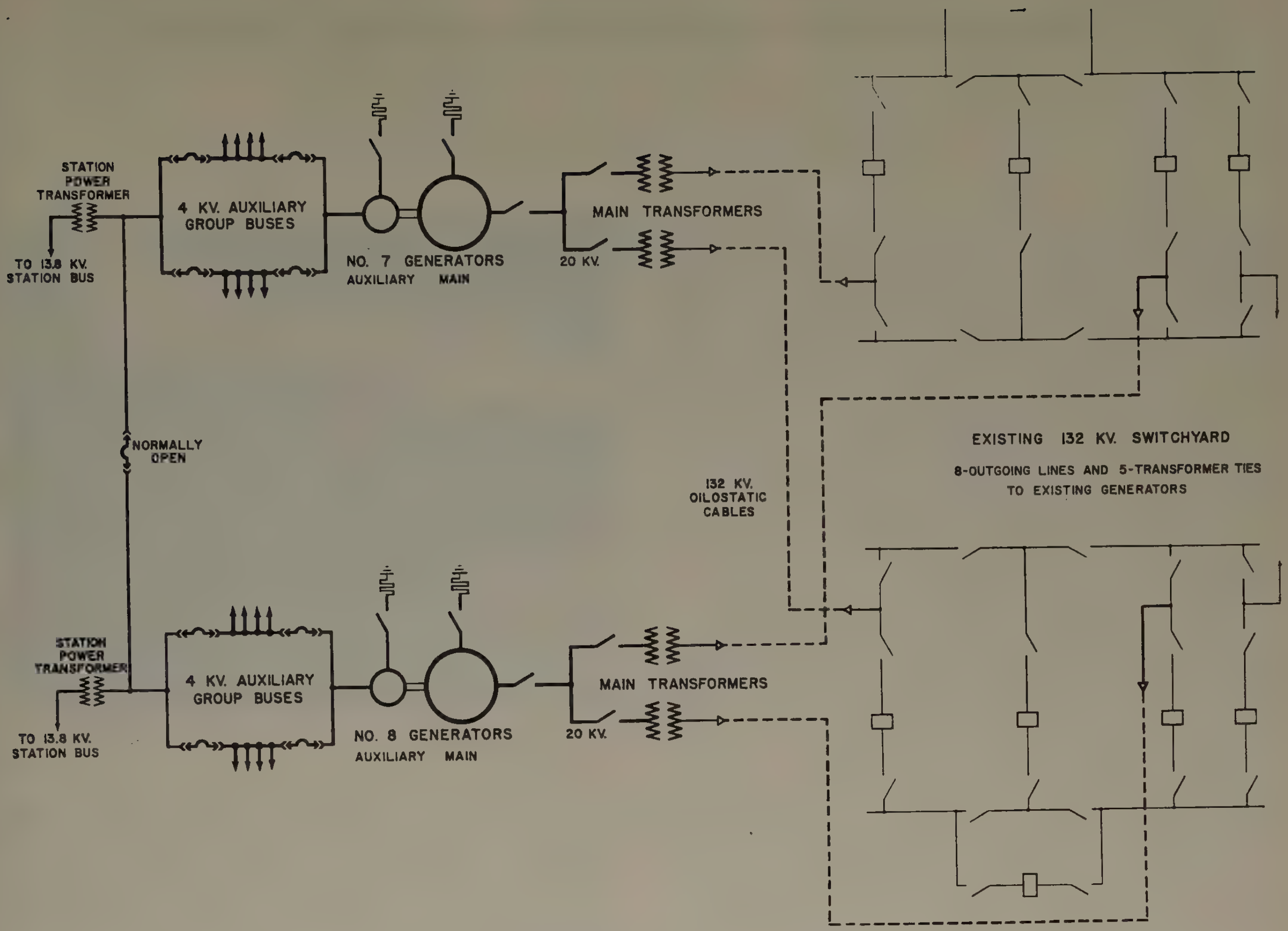

STATION POWER TRANSFORMER
TO 13.8 KV. STATION BUS
4 KV. AUXILIARY GROUP BUSES
NO. 7 GENERATORS
AUXILIARY MAIN
MAIN TRANSFORMERS
20 KV.
NORMALLY OPEN
132 KV. OILOSTATIC CABLES
EXISTING 132 KV. SWITCHYARD
8-OUTGOING LINES AND 5-TRANSFORMER TIES TO EXISTING GENERATORS
STATION POWER TRANSFORMER
TO 13.8 KV. STATION BUS
4 KV. AUXILIARY GROUP BUSES
NO. 8 GENERATORS
AUXILIARY MAIN
MAIN TRANSFORMERS
20 KV.

Fig. 3. One-line diagram of the nos. 7 and 8 units

formers take the output of each unit. The 132-kv leads leave the transformer in cable, thus eliminating the usual bushings and potheads, the cable then enters a 1,000,000-circular-mil oilostatic run to the existing 132-kv switchyard. The pipe is underground or on the surface with sunshades. Conventional connection to the Kearny 132-kv bus makes the output of the new machines available to the 132-kv Public Service system.

Instrument Measures Electronic Noise and Distortion

An instrument capable of measuring electronic noise and distortion in the frequency range from 100 kc to 10 mc has been developed by the Research Division of the New York University College of Engineering.

The tunable noise and distortion measuring set will facilitate research, design, and maintenance of communications equipment in the lower portion of the r-f spectrum, which includes the standard broadcasting range of ordinary radio receivers of 535 to 1,605 kc.

Its principal use lies in the rapidly expanding field of multiplexing electronic equipment, equipment that uses the r-f spectrum for the simultaneous transmission of many messages. The new set enables researchers to measure signal-to-noise ratio per telephone channel, signal to crosstalk ratio per channel, and intermodulation distortion.

Wide-band mean power and the power-frequency distribution of complex signals now can be measured with an accuracy of 1 db. Signal-to-crosstalk ratios as high as 60 db now can be evaluated to within 3 db.

The set permits rapid and accurate verification of theoretical results in communications research and is a means of evaluating systems analyzed by statistical methods.

The dynamic range within which the mean power of complex signals now can be determined is +20 to −80 db referred to 1 milliwatt (0.1 watt to 10 micromicrowatts). By means of a 3.200-cycle bandwidth tunable filter, it is possible to measure the distribution of the power complex signals as a function of frequency. Signals with power peaks of 20 db above the mean level can be measured accurately.

Trends in Automation—Electrolytic Tinning

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THE TIN PLATING industry began in Wales several hundred years ago. Early processes were largely manual, without automatic devices. American ingenuity progressed the art to the modern control giant—the electrolytic tinning line. The modern line has evolved from a pilot line which originally was installed and tested in 1936–1937. The program of automatic electrolytic tinning also was looked upon by our federal government as a good "tin saver." As much as a pound or more of tin could be saved for every 40,000 square inches of tin plate produced.

General acceptance of electrolytic tin plate, together with its favorable cost, has forced nearly all producers of tin plate into this process. Approximately 37 such automatic units are operating in the United States and foreign countries.

Electrolytic tinning lines fall into three major classifications, each related to the type of electrolyte—acid, alkali, or halogen. Another type of differentiation can be drawn from the method used to heat the strip for flow brightening—resistive, radiation, and induction heating.

The selection of a system to control the generators and motors of a tinning line is a problem with many solutions. Automatic operation of all of the functions is mandatory. The physical size of the line is indicated by Fig. 1, which shows only the plating section of the line. Fig. 2 shows that portion of the control associated with the plating operation and strip propulsion through this section of the line.

Each section of the line must be considered a separate system and provided with the required degree of automation. Proper control of loops, tension, speed synchronization, related processes, gauge detection, etc., all must be a part of the general scheme of operation. This requires the use of a number of different automatic closed-loop regulators involving magnetic amplifiers, electronic and rotating-type devices. Close co-ordination of the variables and particular attention to circuit design is required to produce a control embodying all the desirable features.

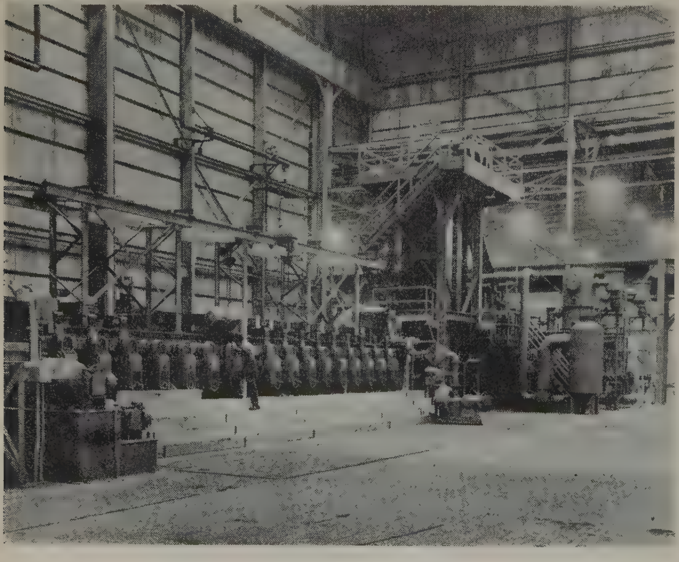

Fig. 1. Plating section of an electrolytic tinning line

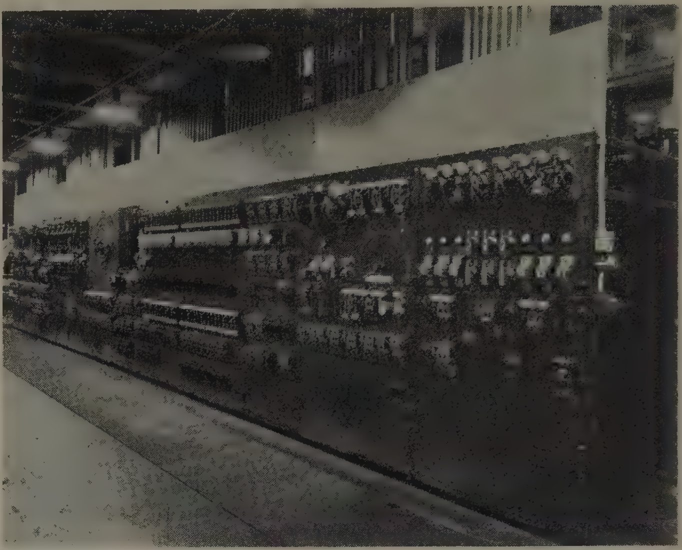

Fig. 2. Magnetic control for plating section of the line

The above related processes are required to run in synchronism and under the supervision of the line operator. This involves the use of many tandem relaying circuits, each of which compels its section of the lines to respond through the synchronizing ties. The entire line may be started and stopped by the operation of a single push button. Individual group control stations are provided along the line to assist the operators in threading, maintenance, or other noncontinuous operations. The real intelligence and sense for line operation comes from the master control station. Here the line speed is selected, the plating current adjusted to produce the desired coating, the melted coating current control adjusted to produce the right flow conditions. All other associated factors are also controlled from the master control station. Circuit design is required which provides continuity of operation, but also permits the operator to make decisions which will resolve difficulties that arise.

Conclusions reached indicate the problem to be one of many ramifications. Careful analysis of each relay function forces co-ordination with all other functions. The general solution to the problem can be found in isolating line functions into groups and attention devoted to these individually after which combinations and recombinations can be made to reach a compatible scheme.

Digest of paper 54-108, "Trends in Automation—Electrolytic Tinning," recommended by the AIEE Committee on Mining and Metal Industry and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Applications and Industry*, 1954.

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Resonant Dielectric Amplifier Frequency Response

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E. R. WINGROVE

THE DIELECTRIC VOLTAGE amplifier shown in Fig. 1 utilizes a nonlinear dielectric (ferroelectric) condenser (capacitor) as part of a series-resonant circuit. This circuit is excited by a carrier source whose voltage and frequency are constant. The capacity of the nonlinear condenser (capacitor) is varied by the signal voltage to be amplified. Of course, a change in the capacity alters the tuning of the resonant circuit, and since the carrier frequency is constant, the circulating carrier current in the resonant circuit is modulated by the signal. The voltages appearing across the elements of the circuit likewise will be modulated. If one of these voltages, usually that across the inductance, is demodulated, a voltage output is obtained which, in a properly designed amplifier, has similar waveshape but larger amplitude than the input signal. Thus a voltage gain is realized.

In the resonant circuit a certain amount of time is required for the circulating current to reach a new steady-state value after any change in tuning. If the signal frequency, and thus the frequency of the tuning variation in the resonant loop is low, the circulating current very nearly may approach the steady-state amplitude required by the tuning at each instant. However, as the signal frequency approaches some fraction of the carrier frequency the circulating current no longer will be able to follow the variations in tuning and the carrier current modulation must decrease in amplitude and fall behind the signal. Since the signal output of the amplifier is proportional to the carrier current modulation this output also must decrease in amplitude and lag in phase for higher signal frequencies.

In addition to the fundamental limitation considered in this article the frequency response of the amplifier shown in Fig. 1 also may be restricted by the signal input and demodulator circuits. It is generally possible, however, to design these circuits so that the drop off in the circulating current modulation is the controlling limitation on the high-frequency response.

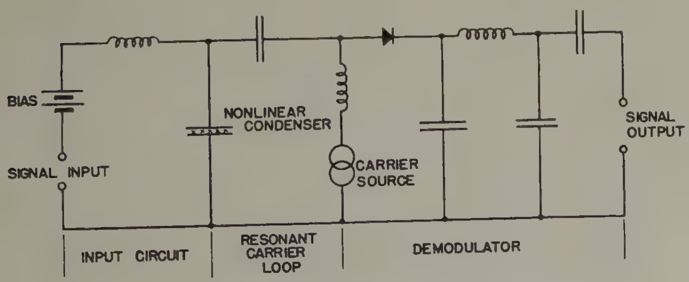

Fig. 1. A resonant circuit dielectric amplifier

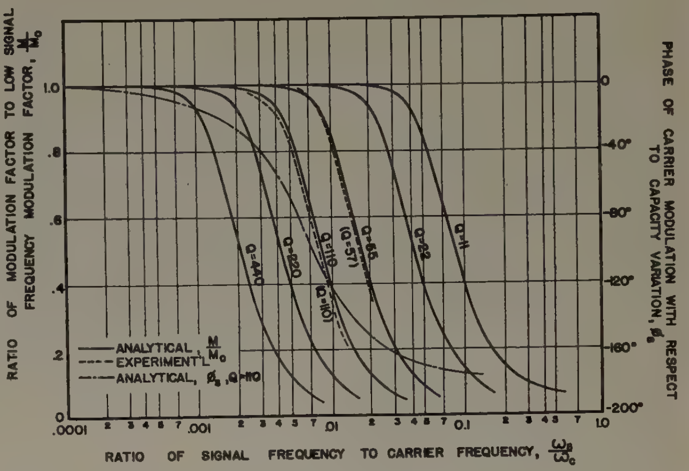

Fig. 2. Modulation amplitude and phase characteristics of the resonant carrier loop

In order to obtain quantitative information on the response of the resonant loop at higher signal frequencies an investigation is made into the steady-state response of a linear element resonant circuit having a sinusoidally varying capacity. It is assumed that the carrier frequency voltage drop across the nonlinear condenser (capacitor) is sufficiently small that it causes negligible variation in the total circuit capacity. Then the differential equation for the circuit under investigation is second order, linear with a time varying parameter. This equation cannot be solved by ordinary methods. The use of an assumed power series solution transforms the task of solving the nonconstant parameter equation into one of solving an array of constant parameter equations, one at a time.

The power series solution of the differential equation leads to the curves shown in Fig. 2. These curves are drawn for values of carrier loop tuning which result in maximum gain for the amplifier of Fig. 1. If the input and demodulator circuits of the amplifier are of proper design the left-hand scale of Fig. 2 represents the ratio of voltage gain at any signal frequency to the voltage gain at very low signal frequencies. Under the same circumstances the right-hand scale indicates the change in the phase of the amplifier output with respect to the low-frequency phase shift which is either 0 or 180 degrees.

For an amplifier with a carrier circuit quality factor of 110 to have a flat response to 10,000 cycles per second it must employ a carrier frequency on the order of 7 megacycles. It can be seen from Fig. 2 that the signal frequency at the high-frequency half-power output point is approximately 0.7 of the ratio of the carrier frequency to the circuit quality factor. If an amplifier is to have negligible phase shift at a particular signal frequency, it must utilize an even higher carrier frequency than that required for a flat amplitude response.

Digest of paper 54-160, "Frequency Response of a Resonant Dielectric Amplifier," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Effects of Recent Scientific Developments on Electronics Education

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The numerous scientific developments of the past decade or so have broadened the field of electrical engineering considerably. Consequently, engineering educators now are asking themselves how their curricula best can meet the new demands. Recent progress has been in the direction of more basic science in engineering, to give the student the underlying concepts from which he can evolve specialized tools and techniques.

THE NUMBER of new scientific developments of the past 15 years which are making themselves felt in one way or another in electrical engineering education is very considerable. The field has broadened from a frequency range of a few megacycles to one of hundreds of thousands of megacycles, from consideration of a single waveform to an infinitude of waveforms, from almost the level of the series or parallel circuit to complex network synthesis. The field has taken over the Fourier integral, Laplace transform, complex variable, Boolean algebra, and matrix algebra. Engineers are continuing to look further in the archives of the mathematical researchers for additional methods, with which they may confound the mathematical researcher by finding that they are good for something. As the physicist has moved into the nuclear field, the electrical engineer has been ready to move into the vacated classical acreages, and has discovered therein much virgin territory still uncultivated. Electron emission, gaseous conduction, electromagnetic propagation, semiconductors, magnetic materials, and ultrasonics are among the so-called classical physics areas now in electrical engineering. In fact, this willingness and ability to take on new fields and new areas as they become available is one of the most encouraging aspects of modern electrical engineering education. It appears that some students actually are receiving a reasonably broad fundamental training and the understanding and the thinking ability to dig out knowledge wherever it may be buried.

SOME RECENT SCIENTIFIC DEVELOPMENTS

TO RESTRICT this discussion somewhat, it seems desirable to select and list a few recent scientific developments which the schools occasionally are urged to teach in one or more aspects. These might include:

1. *Transients.* This is a time-honored word but it no longer means the type of thing generated by a circuit when switch S_1 is open and S_2 is closed. The word now means the generation of pulses and many other waveforms, and the response of circuits to such waveforms.

2. *Servomechanisms.* This is a relatively new word in the language, covering the operations of an old device. Included under this term is much of automatic control theory which is identical to that of servomechanism theory.

3. *Magnetic Amplifiers.* The use of the nonlinearities of the magnetic circuit, which formerly were thought to be limiting and fortunately were, in the analysis of electric machinery. . . . . .

4. *The Dielectric Amplifier.* A new device still in the laboratory stage. What should be done about it?

5. *Rotating Amplifiers.* The new development in the field of machinery wherein machinery transients finally have found their place.

6. *The Transistor.* This device promises to be as exciting as the introduction of the vacuum tube. In less than half a century the vacuum tube radically has altered electrical engineering education. Will the transistor continue this trend?

METHODS OF INTRODUCING NEW MATERIAL

THE FIRST reaction of almost any teacher to this topic is, "We cannot do the present job in 4 years, or 5 years, or 6 years, how can we teach anything more?" This is a perfectly natural reaction of a teacher to the suggestion that additional material be introduced into his courses. It is a perfectly correct response, if new material is to be introduced in addition to that already taught, but it makes one dangerous assumption. Such a statement presupposes a static situation in our present teaching. In engineering teaching static situations may indicate a cause for concern, because things that do not move may be dead. The idea may be expressed in another way; there is only a difference of degree between a rut and a grave.

For the purposes of this discussion it seems necessary to assume that the job of introducing material pertinent to these recent scientific developments will be undertaken. It then must be asked, what channels are available to introduce this material? As much of this material is still debatable, still in the formative stage, it is difficult at the moment to see what is important and what is unimportant from a long-term viewpoint. Thus, a practical solution to the matter is to introduce student electives covering the various areas, to allow those students interested to take those electives, to allow the field to develop, and to allow the teacher to develop his field. This is a customary and reasonably satisfactory way of achieving the desired result.

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954.

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In due time, and with some pushing on the part of the teacher or the department head, as may be required, it may be expected that the appropriate basic material can be expected to filter into the student's required curriculum.

This course is being followed at the University of Illinois. Having had for several years specialized graduate courses in atomic physics and semiconductors taught by Dr. John Bardeen and supported by a program of basic semiconductor and transistor research, this spring for the first time a senior elective on transistor circuits is being presented. This is designed to follow 2 semesters and 13 semester hours of electronics training and will parallel a course in pulses. It will include a fairly complete coverage of the transistor equivalent circuit and the circuit applications of the transistor, building on the previously gained electronic knowledge, and will have a laboratory. At the same time, several fundamental experiments of a previous course are being performed with vacuum tubes replaced by transistors. Thus, the seepage process is already in action.

In many schools this may be the only practical method of introduction, but it will not satisfactorily answer the person who believes the job must be done now. What can be proposed which may answer such a person?

AN APPROACH THROUGH THE FUNDAMENTALS

It seems reasonable that while six new areas of interest have been listed, if engineering fundamentals really are being taught it is possible that fundamentals of these new areas already are included. If so, perhaps by a reorientation of this fundamental teaching, and without appreciable added time, the job may be accomplished. Or, what can be learned from these six new areas about the fundamental materials which educators should be teaching, irrespective of their applications in these new fields?

The fundamentals of transistor operation already should be taught partially in the material on basic electron emission. If the ideas of atomic energy levels in solids, the ideas of filled and unfilled bands and of the energy gap, are introduced carefully at that time, most of the foundation will be laid for transistor theory, and a better understanding of electron emission and conduction also will be obtained. Thus, the job either is being done or can be done with nominal time addition by reorienting work already undertaken at the foundation level. The difference between vacuum tube and transistor lies in the physical phenomena of operation and in the equivalent circuit; after those ideas have been developed the circuit applications follow readily from otherwise-gained electronic knowledge. For instance, an oscillator or a modulator still obeys the same fundamental circuit laws; a push-pull circuit operates in the same way, but with the possibility of use of assymmetrical transistor types added.

It does not appear that the difference between transistor and tube is great, not nearly as great as between tube and machine. A repeat of the electronic upheaval of the past 25 years is not likely and a process of evolution can be followed. If proper foundations are laid at the basic levels, the transistor probably can become part of the advanced electronic courses by use of analogy and some experiments altered to use the transistor.

The subject of pulses and other waveforms, or transients to use an older nomenclature, in many cases already is being handled within the existing framework. It requires a more advanced form of mathematics and again requires a very fundamental understanding of circuits, which cannot be gotten through a circuits course based on the sine wave. In fact, a good course in pulses and non-sine-wave generation and transmission is one of the best educators in fundamental circuit theory that can be devised.

The servomechanism is a circuit involving the idea of feedback. Here again, good circuit analysis work and an understanding of feedback theory provides an adequate foundation. This area, requiring as it does further elaboration of the work in frequency response, feedback theory, phase diagrams, and the like, may require increased time if the job is to be done thoroughly. However, in providing this increased time we should realize that we then are training a servomechanisms engineer, and not necessarily an electrical engineer.

The subjects of feedback theory, frequency and pulse response, and questions of stability, enter into the fundamental dynamics of engineering. As such, they should be taught free of consideration of types of apparatus or "hardware" and therefore should be of fundamental interest to all engineers concerned with dynamic problems. It is well to ask why such a course, free of details in amplifier circuit layout but including fundamentals of gain, feedback, frequency response, and stability analysis, should not be in the curriculum of all engineers interested in dynamic systems. It is quite possible that such a course should replace some of the time now spent in static systems.

Magnetic amplifiers involve circuit fundamentals, especially methods of treating nonlinear circuits. As yet they remain a highly specialized branch of the art and it hardly is thought necessary that all students should have detailed knowledge of their analysis and design. Again, an understanding of nonlinear circuit analysis in some simple form and of feedback, plus knowledge of magnetic field phenomena, should be sufficient.

The dielectric amplifier is new and has not yet proved its complete worth, but here a fundamental knowledge of fields and circuits should be sufficient. The field course should include some consideration of nonlinear dielectric materials as well as of the nonlinear magnetic materials.

Rotating amplifiers, properly a major part of the machinery course, are not yet being taught as such very frequently. They involve basic circuits, feedback ideas, and an understanding of field theory. One should not need to know too much about slots, air gaps, or windings to understand a rotating amplifier. It could be added to existing machinery courses without additional time since it could be used to emphasize fundamental points already taught.

CONCEPTS VERSUS "HARDWARE"

The afore-mentioned devices fall under the category of "hardware," yet to understand their operation and the operation of many other electric devices involves no great knowledge of hardware. In fact, if a job of teaching hardware is to be attempted it can not be done in 4, 5, or 6 years, or any finite number of years. That is a job which industry should and must do, and fortunately seems quite willing to undertake.

It can be noted in the foregoing discussions that certain words were repeated: circuits, fields, feedback theory. This indicates these as prerequisites to the specialties, and requires that they be taught thoroughly for all students, since without them it is impossible for a graduate engineer to have a complete understanding of new devices and applications to be encountered during his professional life. As more and more technical advances appear, engineering teachers are discovering that they should retreat to the old classical subjects—electricity, mechanics, heat, mathematics. Within electricity come the afore-mentioned subjects, among a few others. It should be understood, of course, that these subjects are not being taught as they were in the classical physics courses, but are being taught from the engineering viewpoint.

CO-ORDINATION AMONG TEACHERS

A PROGRAM such as this calls for a great amount of co-ordination between the teachers of sequence courses, and this has not always been obtainable. In fact, it would seem that lack of co-operation and co-ordination between successive courses is one of the great weaknesses of engineering teaching today—not only between departments but between teachers in the same department. Students tend to place individual courses in separate cells and this type of thinking all too often is fostered and encouraged by action of the individual teachers. Better co-operation and teamwork between teachers, and a viewpoint which sees the sequence curriculum as a continuum, not as discrete parts, is badly needed, and should be promoted by administrators.

The schools seem to be teaching more and more of less and less rather than less and less of more and more, leaving to industry the job of specializing in a man's particular field. After all, with the wide scope of opportunities available to the electrical engineer it is certainly impossible to prepare a man for work in any one field at the undergraduate level and it is dangerous to attempt it with a whole class, and this viewpoint is being accepted by educators and industry.

The differences in the teaching of concepts versus the teaching of techniques and tools also are being realized. Both must be taught, but the concepts are of first importance; the techniques and tools must follow and must fit into whatever time remains. As a simple example of this in electrical engineering, Kirchoff's Laws are concepts but circuit analysis is a tool.

INCREASED EFFICIENCY THROUGH NEW TOOLS

ONE OTHER way in which it seems possible to save time, and therefore to find time for introduction of additional concepts or tools, is to systematize present learning: to learn one general method rather than many special methods; to develop and learn general methods of analysis which cover and are applicable to many fields, rather than to learn methods which are specialized to one. A number of examples of this can be given, one being the use of matrix algebra and matrix notation which systematizes circuit analysis, saves time in the solution of circuit problems, and eliminates much of the thinking time required. It allows separation of the dependent and independent variables from the impedance functions and makes possible separate operations on and study of any one. As a result of matrix notation, knowledge of how circuits are put together has been enlarged.

Matrix notation also develops a powerful general tool for electronics wherein the tube can fit into a fairly standardized form, and the transistor does likewise. In addition, transformation of variables becomes a familiar and systematized matter. Such things as polyphase circuits and symmetrical components become merely cases of using the proper transformations on a circuit matrix, not special new tools to be separately learned.

The Laplace transform furnishes another example of this systematization, in that the operator combines within itself the properties of both transient and steady-state solutions for networks, further consolidating and systematizing two broad areas of circuit analysis.

The frequency response viewpoint which has developed in just the last few years also gives information on both steady-state and transient performance. Knowledge of dynamical system performance based on dimensionless frequency-response plots goes far beyond what was known when the frequency response of simple amplifiers was plotted. It now becomes a very valuable tool for predicting the performance of all types of dynamic systems.

These systematic tools, if taught as being of general application, can do much to unify teaching and to save the time needed to introduce new concepts.

MORE BASIC SCIENCE

PROGRESS such as has been discussed is in the direction of more basic science in engineering, a step apparently in line with the recent report of the Committee on Evaluation of Engineering Education (*EE, Feb '54, pp 121–3*). There are those who deplore this and say that engineers must be produced rather than scientists. As a personal matter, the writer has been unable to find a dividing line between a scientist and an engineer, and is unable to see how an engineer can be harmed by being a scientist—if being a scientist means rooting out empiricism and rule of thumb, and replacing them with fundamental laws and reason. Today's graduates are certainly more scientific than they were 25 years ago, and they are better engineers. Whether because of science, or in spite of, is not important.

In general it probably can be agreed that the graduate should be able to think, and should have a knowledge of basic concepts and a reasonable number of tools to operate with them. Undergraduates should not be expected to design a machine, an amplifier, a servomechanism, a tube, or a transistor upon graduation. However, it is hoped that their training is broad enough so that in 10 years they can design any of these devices into a dynamical system. If it is necessary that the undergraduates be permitted a degree of ignorance, let them be ignorant about hardware, but not about the fundamental physical and mathematical factors in engineering. The introduction of recent scientific developments into electrical engineering education then can be handled by ascertaining where they already have been introduced, not where they are to be put.

Compressed Air Circuit Breaker for High Currents

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MEMBER AIEE

J. E. SCHRAMECK
MEMBER AIEE

INDUSTRIES USING large concentrations of electric power at generated voltages have created a demand for circuit breakers and associated switchgear for operation at generated voltages of 12,000 to 15,000 volts, a-c, and at continuous current ratings in excess of 5,000 amperes. The maximum standard current rating for station-type cubicles is 5,000 amperes and is limited by the maximum current rating of the circuit breaker. The problem, therefore, was to increase the limitation imposed by the breaker. The design which resulted is shown in Fig. 1.

Preliminary tests had demonstrated that the standard 5,000-ampere compressed-air circuit breaker could be uprated by forced ventilation of the contacts. It was decided that the connecting bus and disconnecting switches also could be uprated by the same forced air ventilation. Recourse to more massive contact structures was an alternative but this was disregarded due to greater space requirements and limitations imposed by breaker operation where large masses must be accelerated quickly and then stopped without damage to parts or excessive rebound.

An application of these principles recently was made when the continuous current-carrying requirement was 6,000 amperes. The enclosure was weatherproofed for outdoor installation. The breaker and other components were of standard indoor design. Fans were installed in the breaker mechanism compartment as shown in Fig. 1 with baffled and filtered air intakes to prevent the entrance of snow and rain. Condensation of moisture within the unit was prevented by the use of space heaters electrically connected to the fans so that when the fans were not running the heaters were on. The fans, in turn, were controlled thermostatically by differential between inside and outside temperatures such that the fans could not start until inside air had become sufficiently warm due to contact heating and space heating. Thus moisture-laden air from the outside could not be pulled into the housing and deposited on cool insulation.

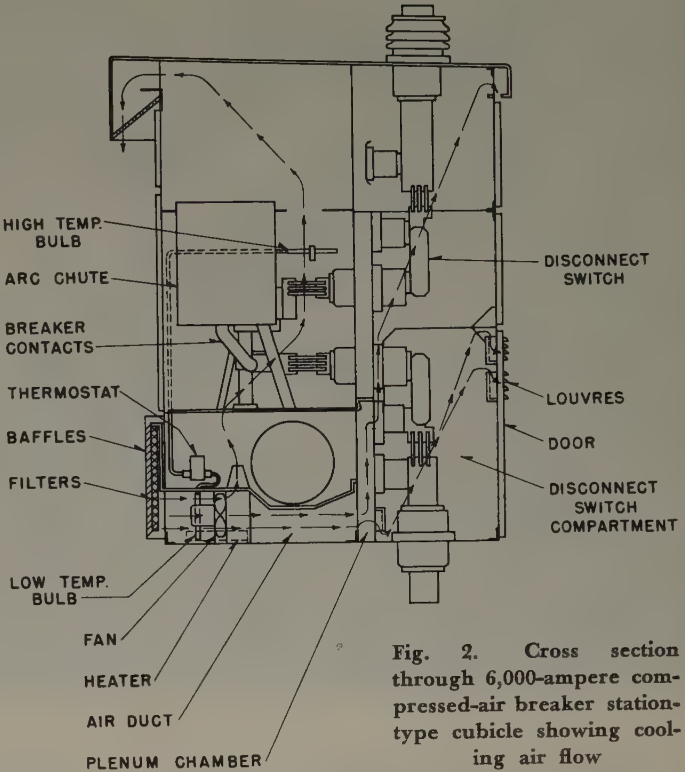

Fig. 2. Cross section through 6,000-ampere compressed-air breaker station-type cubicle showing cooling air flow

Fig. 2 shows the arrangement of air ducts and baffles so that circulation can be controlled to the various components.

Since unequal heating between phase compartments may result from adjacent equipment or from solar energy absorbed on one side but not on the other, the fans are controlled by two differential thermostats mounted one on each side of the unit.

With both fans off maximum temperature rise was 68 C on the disconnecting switches and 61 C on the breaker for 6,000 amperes. For one fan running and at 6,000 amperes, temperature rises dropped to 49 C and 47 C on the breaker and disconnecting switches, respectively. Both fans running were sufficient for cooling the breaker to 53 C rise at 7,000 amperes with air shut off to the disconnecting switches and the switches separately cooled.

The test results have shown that a standard 5,000-ampere station-type compressed-air-breaker cubicle can be converted to 6,000 amperes.

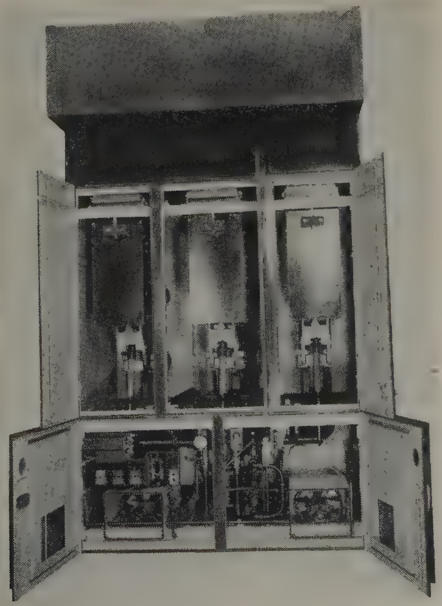

Fig. 1. 6,000-ampere compressed-air station-type cubicle with front doors open showing fans

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Digest of paper 54-131, "A Compressed Air Circuit Breaker for Continuous Currents in Excess of 5,000 Amperes," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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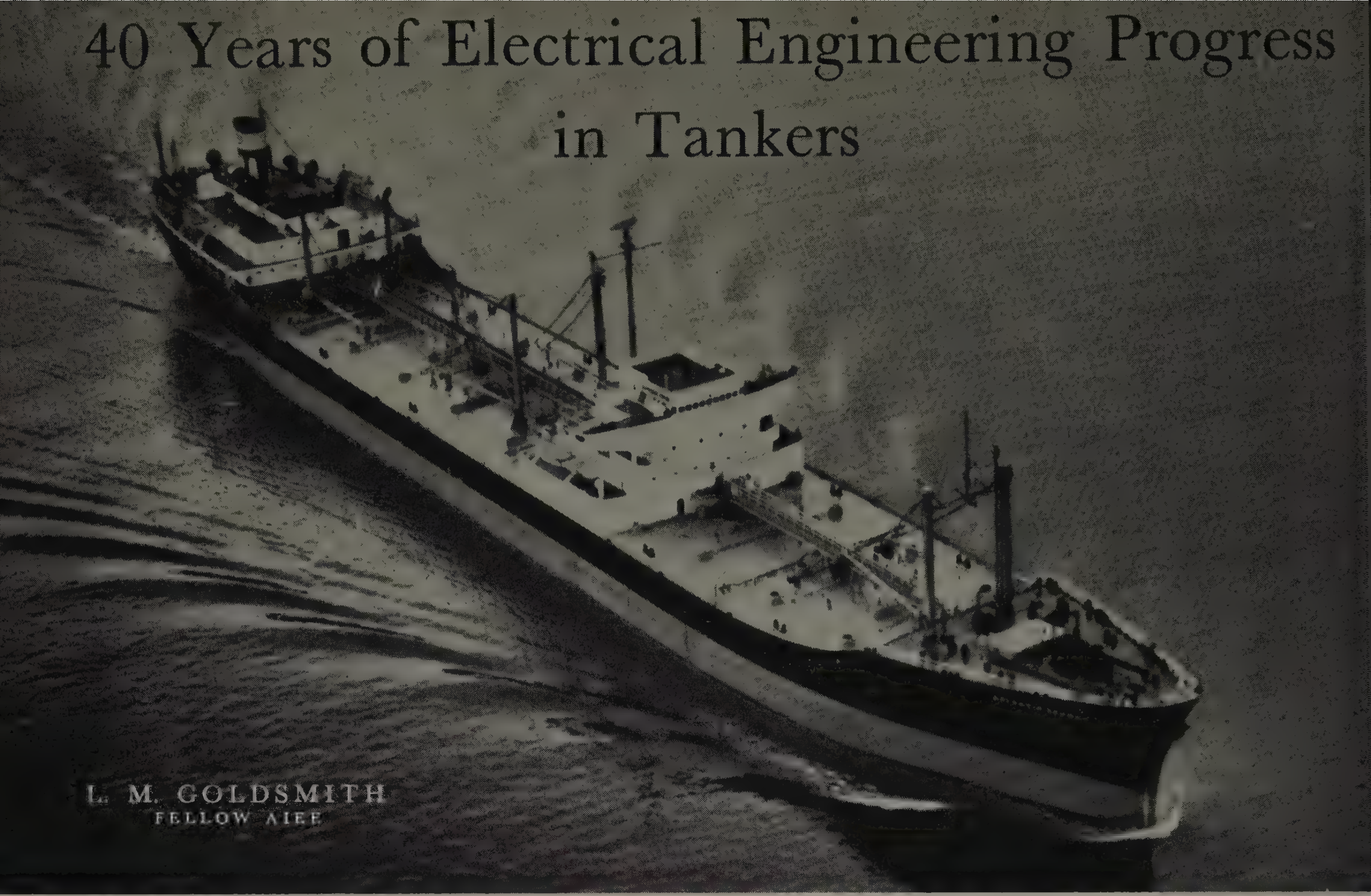
40 Years of Electrical Engineering Progress in Tankers



L. M. GOLDSMITH
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In reviewing the developments of the last 40 years in electrical engineering as applied to tankers the great increase in use and types of applications is emphasized. Electrical consumption has grown from a few to tens of thousands of kilowatt-hours. It is now vital to propulsion, navigation, communication, cargo handling, cooking, safety, and entertainment.

FORTY years ago the only electric power on merchant ships was furnished by a single, vertical, steam-engine-driven d-c generator, which was used for lighting only and rarely was rated at more than 5 kw. Every engine room at that time was equipped with oil lantern stand-bys; all running lights were required to carry stand-by kerosene lanterns built into the electrically lighted running lights. Propulsion power at that time was mostly reciprocating steam engines with Scotch boilers. The first Parsons- and Curtis-type geared turbines were being tried out. Auxiliaries, including cargo pumps, usually were driven by vertical reciprocating steam engines, or direct-acting reciprocating-type pumps, and in many cases practically all of the auxiliaries, with the exception of the steam reciprocating cargo pumps, were driven off the beam of the reciprocating steam engine when used for propulsion.

It also is interesting to recall that at that time the only navigational aids on a ship were a magnetic compass and a sextant, and the steering of the ship was accomplished by a reciprocating steam engine geared to a quadrant on the tiller.

The intervening years have seen electricity for lighting increase tremendously and electric power for auxiliaries and propulsion drives become commonplace, while navigational aids and controls based on electrical and electronic principles have become essential to the operation of a ship. Along with these basic changes have come countless improvements in electric equipment, materials, and techniques.

A striking thing about the growth of electricity in the marine field is the fact that it has followed the pattern of progress in land-based installations. Although marine progress generally has lagged behind by a considerable time interval, nevertheless, it has gone through the same cycle of small d-c machines for lighting only, then large d-c systems for all services, including propulsion, and finally modern relatively high-voltage a-c installations.

It has been contended for many years that machinery does not know or care whether it goes to sea or stays ashore. It is agreed that special problems in regard to corrosion, moisture, vibration, etc., exist on marine installations, but to some extent these same problems are prevalent in installations in refineries and chemical plants. Also, it is appreciated that the ship propulsion unit, including the boilers, requires considerations not usual on land.

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Nevertheless, land practice has been followed as far as it has been possible in the choice and installation of machinery modified to meet classification societies, United States Coast Guard, and other requirements, and it has been the general experience that electric equipment has been adapted easily to marine service. In other words, possibly a better way to state the same thing is to say that marine service has been adapted to existing electric equipment.

After reviewing the course of electrical developments in the marine field, it will be realized that the marine industry has benefited by the tremendous amount of experience and know-how available from land-based installations of similar equipment. This universal characteristic of electrical know-how has given electric equipment a great advantage over other types of equipment. It has meant that the experience and knowledge gained in one field of application has been extended to many other types of services, which in turn has made it possible to support extensive research programs by spreading the costs over all classes of users.

By contrast, consider the case of marine reduction gears. This equipment is used only in the marine industry. The volume of business is small, and as might be expected, the technological progress has been slow and limited to specialized applications within the industry. In fact, it is so slow that there exists as much or more trouble with propulsion gears today than existed 40 years ago.

NAVIGATION AND STEERING

THE most important functions on a ship are navigation and steering. Propulsion may be the oar of a galley slave, the sail of a Chinese junk, or the most modern turbine-gear drive of an *S.S. United States;* but without navigation and steering, the vessel is nothing but a hulk. Therefore, the indispensable instrument used by the mariner is the ship's compass; and the most important auxiliary machinery, without which a ship cannot maneuver, is the rudder actuating steering gear.

The origin of the compass and the time of its first use is shrouded in the mists of long-gone centuries. The modern magnetic compass was devised by Lord Kelvin in the late 1870's. Before and coincident with the ancient loadstone compass were the oars and steering paddles that evolved into the true stern rudder or tiller in the 12th century. The steering wheel first was used early in the 18th century and steam power for steering was applied to ships about 1850.

Forty years ago navigation was by means of a magnetic compass, piloting, dead reckoning, and celestial navigation. Steering gears were actuated by reciprocating steam engines, which were controlled by a mechanical linkage consisting of shafting and gearing between steering engine room and pilothouse. Progress in this type of steering occurred when the mechanical linkage was replaced by hydraulic telemotor control, which in turn was superseded by all-electric control in the form of Selsyn motors. This elimination of pipes and tubing that required constant maintenance to reduce or prevent leaks, with a few wires that were almost trouble-free, was an improvement that was welcomed by the operators as well as the navigators.

It is important for both the helmsman and the navigator always to know the exact position of the rudder in regard to the course of the ship. At this time, mechanical rudder angle indicators were cumbersome and inaccurate. The installation of electrically operated equipment increased the accuracy and reliability of the indicated rudder angle.

During the latter 1920's and early 1930's, the author's company converted some vessels to diesel-electric drives, resulting in the largest diesel-electric fleet of tankers then afloat. When the first three of these vessels were converted, radio direction finders and gyrocompasses were installed, together with gyropilots, used with electrically driven, hydraulically operated steering gear units.

The gyrocompass first was demonstrated experimentally by Foucault early in the 1850's, but was not utilized until 1910, when it was used by the U. S. Navy to overcome difficulties incident to the use of magnetic compasses on war vessels. After World War I, commercial vessels began to use it with its attendant auxiliaries: the gyropilot, or better known "Metal Mike," which gives automatic steering; the steering repeater compass for indication of the course to the helmsman; and the gyrocompass course recorder, for recording the course of the ship and time.

These same navigational aids with improvements were installed on all subsequent ships built and operated by this company and new aids were added, such as radio direction finder, fathometer, radar, and Loran. The direction finder is just an electronic means of finding the direction of the ship from the shore stations, and by obtaining a fix on two shore stations the approximate position of the ship can be determined. By the fathometer it is possible to know the depth of water being navigated at all times; and it is far more accurate than any other means, as it is accomplished by electronically measuring the time for a sound wave to reflect through the water from the bottom, which is translated into measurement of depth. Radar is an electronic means of seeing what is around a ship by the way of objects and is used when these objects are not visible to the eye. Loran is used to tell the position of the ship really by electronic triangulation, including the measurement of distance. In other words, it is possible today to navigate a ship electrically practically any place in the world without the use of a magnetic compass or an astral observation. This, together with the gyropilot, greatly increases the efficiency of a vessel. The gyropilot electrically steers a true course automatically better than a human being can, and as electronic navigation holds the ship to a true course regardless of drift, wind, or tide, it can be proved that the shortest distance between two points is a straight line. In the older form of navigation, navigation between the two points was, of necessity, a zigzag.

It should be noted these tremendous strides, accomplished by the use of electricity to aid in navigation and steering of a vessel, have been accomplished in these 40 years, which is an almost infinitesimal length of time when you think of the long history of men and ships. These navigational aids have eliminated most of the drudgery

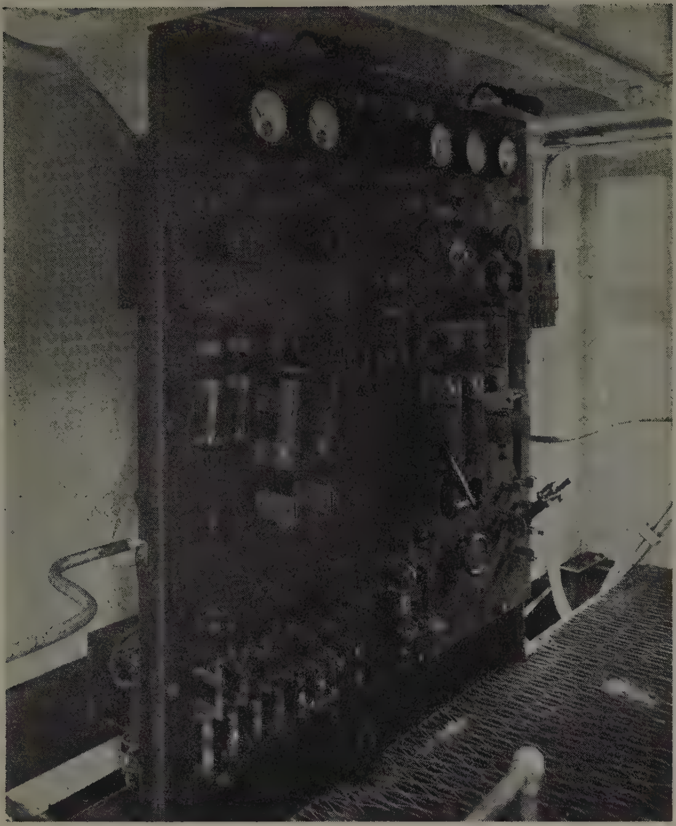

Fig. 1. Main switchboard on the world's first diesel-electric tugboat Van Dyke 1, photographed in 1924. Note live-front switchboard

and guesswork from the job of moving a ship safely from port to port in a minimum of time, approaching that push-button age where eventually the technician, known as the chief engineer of the ship, also will be the captain.

PROPULSION

This first group of tankers were propelled either by compound turbines with single reduction gears, or by 3- and 4-cylinder reciprocating engines. Our second group of tankers were ships of similar design to the first group, but were converted to diesel-electric propulsion. This came about, of course, through the development of the solid injection diesel engine and the improved reliability resulting from diesel-electric drive where more than one prime mover was used.

These diesel-electric ships featured two, three, and four constant-speed diesel engines driving 250-volt (maximum) d-c generators and 125-volt auxiliary generators (exciters), both of which were on the same shaft. Any generator could be operated individually on any propulsion circuit or could be connected in series with the other generators for operation of one or more. Thus the maximum propulsion voltage varied from 250 with one generator to 1,000 for four generators; and with the generators all connected in series, any engine could stop at any time without affecting the propulsion of the vessel, except to slow it down due to the reduction in voltage of that one generator not operating. The electric drive has the added advantage of full power astern not possible in any geared turbine drive.

Propulsion control on these vessels was based on the familiar Ward-Leonard system modified to suit our needs. Manual controllers were provided in both the pilothouse and the engine room. The control was designed to prevent a too sudden application of the propulsion load and a consequent loss of power at a time when conditions might mean danger to the ship, because it must be kept in mind that while the revolutions of a propulsion motor on a d-c drive vary directly with the voltage, the horsepower varies as the cube of the speed. Therefore, it is obvious if the voltage were applied in equal increments, and at the same rate, great overloading could occur. Another advantage of this form of control is that only 2 per cent of the total current in this system, which is the exciting current for the generators, is necessary to control the propulsion motor.

In the application of electrical engineering to this form of drive, much was taken from land-based electrical practice. The design of motors and generators, for instance, was based on steel mill equipment, and the development of fabricated rolled frames for both generators and motors was applied with a saving in weight and an improvement in efficiency. Even the well-known Printing Press control was utilized for the control of the exciting current and thus the control of the propulsion motor. This is just a motor-driven rheostat arranged to so apply propulsion motor voltage that the propeller speed will be such that power will be a constant.

After our development along diesel-electric lines, including the first diesel-electric tugboats—see Fig. 1, it was realized that to go to the higher powers necessary for the continually increasing size of tankers, was going beyond the realm of the diesel engine, unless the very heavy low-speed direct-connected diesel engine was used. Just before World War II, when a great replacement was required in our fleet, studies indicated the use of high-pressure high-temperature steam. Again, this was based on the fine efficiencies being produced by such power plants on land and thus vessels with steam turbine-electric drive were planned. At that time geared turbines could not be used at high pressure and high temperature on account of overheating the separate astern turbine not needed for electric propulsion.

It was in 1938, therefore, that the first of our Van Dyke class of turbine-electric tankers went to sea. Here again, electrically, we went ahead of the entire marine field in our application of electricity. Our designs were somewhat simplified in this by going to a-c drive, because of the great advance made in alternating current on land. We merely were following a good practice which we had established and proved in our own refineries in this application. The main switchboard on the early turbine-electric drive *S.S. J. W. Van Dyke* is shown in Fig. 2.

While this, primarily, indicates the application of electrical engineering to tankers, it is well to state here that the Van Dyke class of turbine-electric ship started a new era, not only in tankers but in the entire merchant navy.

The first two of these vessels were 650-pound pressure steam at 835 F and the next seven vessels were 650-pound steam at 920 F. While there was much criticism leveled for this unorthodox step, it should be noted that 850-pound steam pressure at 850 F is practically standard today in the U. S. merchant fleet, and a bit on the conservative side. The marine people, true to tradition, waited practically 15 years to observe this operation before making it a standard. The main switchboard on the *S.S. Atlantic Seaman*, which has the highest temperature steam on any merchant or naval vessel, is shown in Fig. 3.

Considerable satisfaction has been derived from the fact that these ships were the prototype for the *T2* tankers of which the U. S. Maritime Commission constructed more than 500 during World War II. It must be said here this number of tankers could not possibly have been built in that length of time with turbine gear propulsion because there did not exist then, nor now, enough gear-cutting machinery in this country to produce the needed gears in anywhere near the required time.

On the Van Dyke class of vessels, the propulsion generator is a standard design unit of 4,500 kw, 60 cycles, 3 phases, 2,300 volts, at 3,600 rpm, with water cooler mounted under the generator, but housed in the same enclosing unit. Ventilation is provided by fans integrally mounted on the rotor.

The propulsion motor is of the synchronous induction type rated at 5,000 shaft horsepower, 90 rpm, 2,300 volts, 3 phases, unity power factor. As required in all main propulsion units, these motors have a nominal overload rating of 10 per cent. The separate pedestal-type bearing construction used so successfully on our diesel-electric ships was applied here on the main propulsion motor, using a disk and wiper method of lubrication making these huge main propelling motor bearings independent of all other systems above the vessel, including an overhead gravity tank which is usually empty.

The control for the propulsion setup is located in the engine room in the conventional manner and is extremely simple. There are three large manually operated levers: one, the setup switch that determines the ahead and astern movement and opens or closes in proper sequence both the generator and motor field contactors; the second lever operates a turbine governor which varies the speed of the turbine and thus controls the generator output frequency, which in turn determines the speed of the main propulsion motors; and a third lever, which is an emergency throttle lever that operates directly on the turbine throttle. In other words, the entire control of the propeller is by frequency control and actually the vessel is propelled through an electric gear so that the propelling motor speed always is locked into the speed of the main turbine generator. In addition, full power astern is always available by merely reversing the propulsion motor.

Here the propulsion circuit protection consists of phase balance and ground relays, and the generator field is protected against current flowing through it when shut down.

These vessels all have electrically driven cargo pumps and, it is believed, still hold the record for fast discharge, as one of them has been pumped out in 8 hours and 50 minutes with a cargo of 150,000 barrels of oil. Another advantage of electric propulsion is the great amount of power available for the cargo pumps. When in port the turbogenerator runs just the same as a land generator at 3,600 rpm, 60 cycles, 2,300 volts, and the vertical deep-well type of motor-driven cargo pumps located amidship are driven by 2,300-volt motors. It should be noted here that, as far as is known, these are the only 2,300-volt cargo motors afloat. They have been operating 15 years without trouble and without a cable replacement.

SHIP'S SERVICE GENERATORS

The tremendous increase in the use of electric power for lighting and driving auxiliaries on tankers has been mentioned. It is difficult to realize that in scarcely more than 40 years the single vertical, steam-engine-driven generator of 5 or less kilowatts has been replaced by at

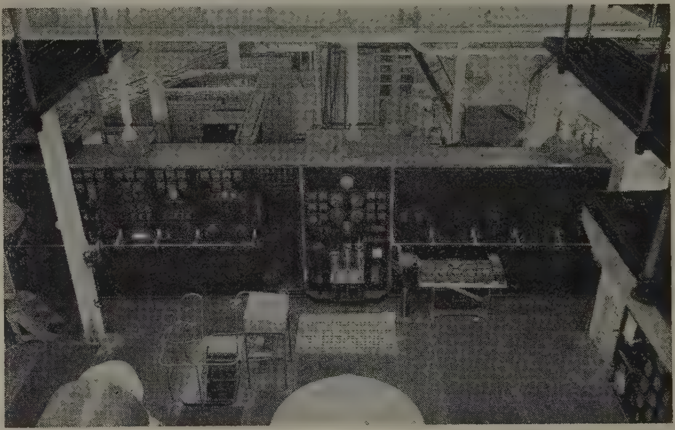

Fig. 2. Main switchboard on the turbine-electric drive S.S. J. W. Van Dyke, which went to sea in 1938. She was the first ship to use 600-pound steam at 900 F

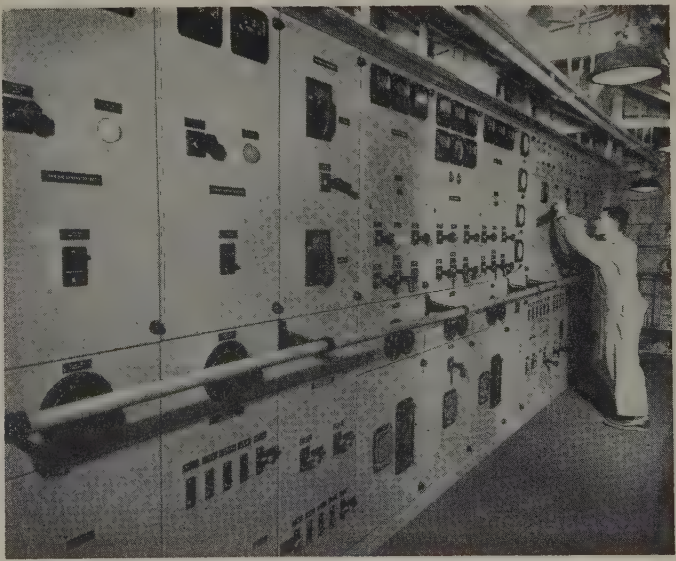

Fig. 3. Main switchboard on the S.S. Atlantic Seaman, which went to sea in 1950. She has the highest temperature steam on any merchant or naval vessel: 650 pounds at 1020 F

least two ship's service turbines or diesel generators set with ratings up to 750 kw, in addition to a stand-by or emergency unit rated usually at 125/150 kw.

This increase in the use of electric power, though phenomenal, was gradual. Originally only lights were electrified, then the ship's wireless telegraph, quarters' fans, and searchlights were added. Later the lubricating oil centrifuge units, the ice machines, and the machine shop were converted to electric-motor operation. In turn followed electric hydraulic steering gear and motorization of the various pumps, fans, and other equipment. Today's tankers have all auxiliaries operating electrically, with the exception of the feed-water pumps which are turbine driven. In some cases even they are motor driven where the heat balance on the vessel shows it to be an advantage.

Another innovation that we introduced for tankers was accomplished on the Van Dyke class vessels. There are two ship's service turbo-auxiliary sets consisting of a 6,000-rpm turbine driving through gears a 350-kw 50-cycle 1,200-rpm 450-volt 3-phase synchronous generator; a 65-kw 110-volt d-c generator to furnish excitation for the propulsion units; and a 20-kw 120-volt d-c generator for exciting the 350-kw generator and supplying miscellaneous d-c requirements.

Switching is so arranged that under normal conditions (50/60 cycles) the propulsion generator may be paralleled with either of the ship's service sets to furnish 440 volts auxiliary power through a bank of pyranol-filled transformers. During this condition the nominally 350-kw a-c generator operates as a synchronous motor to drive the d-c machines and turbine. No cooling of the turbine is required, as vacuum is maintained through a connection to the main condenser. When the speed of the main generator drops to approximately 52 cycles, the speed governor of the ship's service turbine automatically starts to open the steam emission valve, and this set assumes its full auxiliary load by the time the main unit has slowed down to 50 cycles. The parallel circuit breaker between the propulsion and ship's service generator opens automatically to prevent the latter taking any of the propulsion load. It is necessary to increase the speed of the ship's service generator from 52 to 60 cycles manually.

This parallel operation of the main propulsion generator and the ship's service generator has been called "motorized operation." It has been highly successful on these ships because, due to the difference in water rates between the main and ship's service turbine, appreciable saving in fuel is effected in a yearly period.

A few years after World War II, our company built three supertankers to our own design. These ships are geared-turbine propulsion.

In addition to the conventional two marine-type ship's service turbine-generator sets, which are rated 750 kw, there is a 700-kw a-c generator, which is driven from the second reduction pinion of the propulsion gear unit and is mounted on, and forms a part of, the propulsion unit. This generator, which usually is not found in marine installations, is designated the "attached" generator and is arranged for "motorized" operation with either of the two ship's service generators under full speed conditions of the ship. The scheme of operation is very similar to that described on the Van Dyke class of turbine-electric ships.

A 125-kw 440-volt 3-phase 60-cycle 1,800-rpm diesel-driven stand-by unit completes the generating equipment on these ships, but is used only in an emergency.

It should be noted that this idea of an "attached" generator on a geared turbine ship was not original with us, but was originated by W. W. Smith, then chief engineer of the Federal Shipbuilding Company, and applied to two Esso tankers. However, it was done with d-c generators and though at that time it did not indicate enough advantage for it to be used by other builders and owners, it was adopted by us and results in a great saving in fuel on these vessels which make a 17,000-mile voyage to the Persian Gulf. Where there is very little maneuvering done in such a long run, the obvious advantage of an "attached" generator can be seen.

AUXILIARY MOTORS

Our experience with electrically driven fans, pumps, etc., in our refineries led us to investigate this type of equipment for our first ships. The decision to electrify all auxiliaries on our diesel-electric vessels was not arrived at easily, as it was then difficult to allay the ignorance and suspicion of electricity by nearly everyone in the marine industry. However, the constant-speed diesel engine, driving both propulsion and auxiliary generators, provided a very economical source of power and justified our application of electric motors not only to auxiliaries but also to cargo pumps.

All of the motors on these first ships were direct current and in the engine room were of the enclosed ventilated type. On deck and in hazardous locations we used what then passed for explosion-proof motors. All these motors had sleeve bearings and were ring oil lubricated. We early learned that while ring-oil-lubricated bearings in some applications are nearly trouble-free, they leave much to be desired when installed in small auxiliary motors aboard ship.

On our turbine-electric ships and our supertankers, all pumps and fans are ball bearing, grease lubricated, Class *II*, marine type, totally enclosed, except the Class *I*, Group *D* motors located in hazardous areas or on deck. All vital auxiliaries, such as steering gear, lube oil pumps, and forced draft fans, have been provided with automatic restart push buttons so timed as to start each of these vital motors in preferential order to prevent excessive starting current on the generator after an unscheduled shutdown.

CARGO PUMP MOTORS

The cargo pumps of our diesel-electric ships were so large it was necessary to drive them from the "main power bus," to which could be connected any one (but only one) of the main propulsion generators. The cargo pump room was located in the after part of the ship, immediately forward of the engine room. The cargo pumps were located in this room and were driven by motors, which were located in the engine room with the shaft extending through bulkhead stuffing boxes. Thus, it was not necessary to install any electric wiring or equipment in the pump room, which eliminated a serious fire and explosion hazard and is a practice that has been continued in all of our tankers.

On the Van Dyke class of ships the cargo pump room is located just after the amidship house, with the motor room on the main deck completely separated from the pump room directly below. The cargo pumps are 3-stage centrifugal units of the deep-well type driven by explosion-proof 300-hp hollow-shaft vertical motors, rated 2,300 volts. It is believed that these were the first motors of this voltage rating to be installed aboard ship for other than propulsion purposes.

The motors normally are connected to the main propulsion bus and operate directly from the main propulsion generator. While pumping either cargo or ballast, the rate of pumping may be changed merely by changing the speed of the main turbine. These pumps can be operated successfully at approximately 40 cycles, and in addition they will run without damage either to motor or pump throughout the full speed range of the main propulsion generator. This is because the voltage regulator equipment for the main propulsion generator is designed to hold volts per cycle over the complete range of the generator (1,080 to 3,600 rpm). As has been indicated previously, if necessary the power for pumping may be taken from the ship's service turbogenerator sets through a bank of pyranol-filled transformers, and when thus used serve as step-up transformers.

On our supertankers the cargo pump room, as was the case on our diesel-electric ships, is located in the after part of the ship immediately forward of the engine room, with the cargo pumps in the cargo pump room driven by motors located in the engine room, with the stuffing box on the shaft between.

SWITCHBOARDS AND CONTROL

As RECENTLY as 20 years ago, regular commercial practice was followed in the general design of marine switchboards, which meant the circuit breakers, fuses, switches, and all other live parts were mounted on the front of the panels. This presented a continuing hazard to engine room crews.

The hazardous live-front switchboard was discarded and our first application of the dead-front switchboard was made on our diesel-electric vessels. With only the electric meters, the operating wheels of the setup switches, and the handles of the various auxiliary switches showing through the front of the switchboard, and with a grab rail and rubber mat along the entire length and front of the switchboard for additional protection, a new degree of safety to the engineers was provided.

All of the propulsion control, setup switches, bus work, relays, auxiliary generators, switches, and other live parts, as well as all engine room auxiliary motor controllers, were mounted at the rear of the switchboard. The auxiliary motor controllers were grouped together on ebony asbestos panels without covers and made up our first "group control." The ends of the switchboard were enclosed to prevent either damage from or to unauthorized personnel.

This method of grouping our controls is a practice we have found highly satisfactory and have followed it on all of our installations, land or marine, wherever practical. It has been found desirable because the individual controllers are readily inspected and maintained; there is a saving of valuable space; they are protected from abuse or damage in the crowded operating area; there is no possibility of trouble from oil, steam, or water leaks; and on board ship the area where the "group control" is installed is not affected by wide temperature variations. They also are not exposed, in any way, to leakage of steam or water lines, etc.

Since the ambient in this area and the ambient at the motor could and often does vary considerably, special thermally compensated temperature overload relays, adjusted to allow for such temperature differentials, were furnished with the controllers to provide motor overload protection. They have proved highly satisfactory and we are proud to state this idea originated with us.

DISTRIBUTION

PRESENT-DAY distribution systems on ships of American registry are a considerable improvement over the systems of 20 or more years ago. Some of you may recall ships which were wired with the hull used for ground return. Today in Europe ground distribution systems are common, while U. S. Coast Guard Tank Vessel Regulations forbid the use of ground connections here.

Our first tankers, 37 years ago, had wiring in conduit and great difficulty was experienced with it due to corrosion of, and moisture in, the conduits, and as a result we established a policy of using the then "Navy" type of cable to replace defective wire and conduit. Today, this Navy cable is known as "Marine"-type cable, and for our installations we specify varnish cambric insulation, lead covered, with bronze basket-weave armor.

On all of our ships detailed cable layouts have been insisted on to insure a workmanlike installation. Each cable is marked by metal tags at a number of places for ready identification. Installation is made on steel plate runways by means of lead-lined cable clamps preformed to fit tightly against the cables, thus precluding any cable chafing. This method of mounting the cables on steel plate runways was devised in order to protect them from mechanical damage; to facilitate location of trouble in any cable; to make easy identification or replacement of any defective cable; and to permit painting of areas in back of the cables that otherwise could not be painted and would rust. Our experience over the years with this type of cable and construction has been excellent.

With today's high labor and material costs, it would be well for those who are responsible for both shore and marine installations to study carefully the comparative costs between a standard land installation of conduit and cable and a normal marine installation of armored cable, since under certain conditions it is conceivable the marine-type installation can be justified economically over the conduit and cable. Based on work over this period of years in electrical installations, the prediction that land installations now will follow marine installations and use cable instead of wire in conduit is ventured.

LIGHTING

One of the earliest impressions of all ships, but in particular of tankers, was the dinginess and dirtiness resulting from poor lighting. This was especially true in the machinery spaces. Old timers will recall that 25 years ago shipboard lighting in general was a haphazard affair, consisting of an occasional carbon filament lamp hung in some indiscriminant place by an entirely disinterested electrician. The emergency and stand-by lighting was furnished by oil lanterns. Even today, engine room lighting on most ships leaves a great deal to be desired.

The low intensity of the engine room lighting and the dearth of satisfactory lighting fixtures led us to the use of land-type floodlights in the engine rooms of the first ships we converted. The increase in wattage, with careful location of each floodlight to secure an even distribution throughout the entire machinery space, resulted in an appreciable reduction in the number of fixtures that otherwise would have been used. The improved lighting facilitated the correct observation of the various machinery by the engineers and assisted them greatly during maintenance periods. It proved so satisfactory that it has remained our standard method of lighting engine rooms.

Lighting is furnished to the cargo pump rooms on all of our vessels by means of an explosion-proof fixture which is located externally to the cargo pump room with sealed bulls' eyes providing the lighting into the pump room.

Quarters' lighting on most ships, including passenger vessels, in the past was only slightly better than that found in the machinery spaces, but since World War II much thought has been given to this problem resulting in considerable increase in the lighting intensity in these areas.

On our supertankers fluorescent lighting fixtures are used for general quarters' lighting, mirrors, bunks, and desk lights. Each ceiling fixture in the quarters employs a 30-watt fluorescent lamp with two $7^1/_2$-watt incandescent lamps in the same fixture. The use of the $7^1/_2$-watt incandescent lamps was an innovation to provide instantaneous light when the switch is pushed on.

On our a-c ships there are occasional voltage variations, due to the volts per cycle generation characteristics, and in order to maintain constant voltage on the lighting system d-c saturated-core reactors are used with the lighting transformers on one class of vessel, while standard induction voltage regulators are utilized on the other class. Both schemes have given satisfactory results.

GALLEYS

The first of our electric ships had oil-fired galley ranges with all dough mixing, potato peeling, meat cutting, and dish washing done by hand. This appeared inconsistent to us, but again it was necessary to overcome the natural inertia not only of the marine people but also of the manufacturers before electric galley equipment could be applied to these vessels.

Standard commercial electric ranges were used first and there was considerable difficulty with them because of grease fouling up switch contacts, wires breaking due to vibration or heat embrittlement, etc.

Today, all of our vessels have electric galleys and though only a few manufacturers design galley equipment for marine service, we have been unusually successful in securing designs of ranges, dishwashers, dough mixers, bake ovens, potato peelers, etc., which have proved highly satisfactory. By moving all the switches off the range and mounting them remotely, the difficulties due to grease and dirt have been eliminated. Improvement in the type of wire used in the heat zone, usually nickel-chrome, has eliminated most of the wire breakage.

MISCELLANEOUS

Minor changes and improvements to various ship's auxiliaries and their electrical components are being made constantly because of operating experience, improvement in the art, and general upgrading of requirements.

There is a trend toward the use of circuit breakers instead of fuses because experience with both has indicated the circuit breakers provide more positive protection with more accurate operation. The use of circuit breakers also eliminates the hazard of operating personnel altering the settings as they did with fuses.

Many tankers now are provided with sound power telephone systems for intercommunication purposes; ship-to-shore telephones for positive communication between the ship and shore stations; docking loudspeaker systems to facilitate docking the vessel; electrically controlled air-puff-type soot blowers; and recording salinometers for continuous check of condensate purity and detection of condenser tube leaks.

In quarters there is a radiobroadcast antenna system for the convenience of the entire crew.

There has been a continuing improvement in living accommodations and recreational facilities on board ship during the past 40 years.

In this brief review an endeavor has been made to point out the great increase in the use and application of electricity to shipboard service. Forty years have seen electrical consumption grow from a few kilowatt-hours to tens of thousands of kilowatt-hours. Electricity now plays a vital role in all phases of ship operation: propulsion, navigation, communication, cargo handling, cooking, safety, and entertainment, so that living conditions at sea have been greatly influenced by the progress of electricity.

Most of these changes have come about as the result of progress in land-based applications. Often the marine industry has been slow to accept new developments in the electrical field. There are signs that this is changing.

The first full-scale atomic power plant, now under construction for the U. S. Navy, will be a marine installation. Undoubtedly, much will be learned from this pioneer marine effort applicable to similar shore-based power plants.

What the future holds, no one knows. It is clear that great things have been accomplished in the past, but the surface has been only scratched. A prediction of the nature and timing of future developments will not be attempted; however, it is certain that great challenges and great progress lie ahead. If engineers accept these challenges with open and alert minds, then problems will be solved with facts rather than hidebound fancy or bias.

Green's Functions in Evaluating Fields

J. J. SMITH
MEMBER AIEE

IN A PREVIOUS paper[1] it was shown how expressions for vector potential could be derived from corresponding values of scalar potential for a point source which are given in Tables of Green's Functions previously published.[2] It then was shown how these expressions for vector potential could be used to derive the electromagnetic fields due to uniformly magnetized disks, or due to coils by building them up from magnetic doublets or individual current elements by integration. The examples given in that paper[1] were limited to those in which the field did not vary with time, since some additional concepts need to be introduced when the field varies with time.

The method is fairly simple and may be described briefly as follows. To find the field due to a current in a conductor, the conductor is divided up into elements of length ds. At each of these elements there is considered to be an instantaneous point charge Q_1 moving with a velocity u with components u_x, u_y, and u_z. The scalar potential v due to this instantaneous charge then can be found for the given boundary conditions from the Tables of Green's Functions. Having obtained the scalar potential v, it is well known[3] that the solution of Maxwell's equations for the vector potential A with components A_x, A_y, and A_z is, ϵ being the permittivity,

$$A_x=\epsilon v u_x, \quad A_y=\epsilon v u_y, \quad A_z=\epsilon v u_z$$

The value of A thus obtained is integrated with respect to time from a time t_0 when the current is started in the circuit up to the present time. This result then is integrated over all the elements of the circuit to obtain the vector potential for the complete circuit.

The procedure is analogous to the use of Ampere's Law for the field due to a current element, but extends it to cases where (1) there is variation with time; (2) the boundaries of the space are at finite distances; (3) other co-ordinate systems are used. Thus Ampere's Law is only one particular result among a whole host of results which are given in the Tables of Green's Functions and which are needed in dealing with different problems. The use of these Tables of Green's Functions may be illustrated by several examples for which the corresponding fields are derived as follows:

1. The magnetic field due to a constant current I or current $I \cos w(t-t_0)$ starting at the time t_0 in a straight wire of infinite length.
2. Derivation of Ampere's Law.
3. The magnetic field due to a current $I \cos w(t-t_0)$ starting at the time t_0 in a straight wire of finite length.
4. The magnetic field due to a current $I \cos w(t-t_0)$ starting at the time t_0 in a rectangular coil.
5. Comparison of expressions for vector potential due to a constant current and a sinusoidal current.
6. The relation of vector potential to the terminology used in resonant cavity and waveguide theory.
7. Resonant cavities.
8. Waveguides.
9. The use of other co-ordinate systems.

It is surprising in this method of approach how many different problems can be evaluated from a single result obtained from the Tables of Green's Functions. For instance, starting with the expression for the field due to an instantaneous point source in free space (boundaries at infinity), the field is obtained readily due to a current which may or may not vary with time in a straight wire of finite or infinite length or a rectangular coil (or for any coil if we approximate it by suitable rectangles). Similarly, in the case of a resonant cavity or waveguide, the instantaneous point source is chosen from the Tables of Green's Functions which satisfies the conditions to be met at the boundaries of the cavity which are now at finite distance.

The procedure described fills a gap which has existed in the calculation of fields by the use of circuit theory and by the use of the wave equation of Maxwell. In recent years the distinction between the two approaches has been growing less and less, as is evidenced by the necessity of using Maxwell's equations in connection with resonant cavities and waveguides. The solution of Maxwell's equation corresponding to the instantaneous point source or the Green's function is admirably adapted to giving expressions for the field due to a charged particle at rest or in motion.

When the field due to an instantaneous point source satisfying the required conditions is obtained from the Tables of Green's Functions, only the operation of integration is needed in the cases illustrated to meet the other conditions in the problem. It is not necessary to go back in each case to Maxwell's equations and endeavor to find a solution from them directly which satisfies all the given conditions.

It may be pointed out also that the solutions obtained contain not only the "steady state" solution, but also the "transient" solution which ensures that at a distance r from the source, the field is zero when $r > c(t-t_0)$ so that a wave traveling with velocity c has not reached the point.

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Development of Good AIEE Public Relations

R. T. FERRIS
MEMBER AIEE

The chairman of the AIEE Committee on Public Relations discusses the committee's 1954 plans for a national co-operative public relations program in line with its desire for better understanding by the public of what the electrical engineer means to the nation and to the community.

IT IS now time to take another step ahead in the further development of a forward-looking program of public relations for the AIEE. The 1954 program as envisaged by the AIEE Committee on Public Relations with the continuing support and active co-operation of the Institute leadership and membership throughout the country should rebound not only to the benefit of the organization, but to a better and wider understanding by the public of what the electrical engineer and his profession contribute to the progress and welfare of the entire population.

The Committee on Public Relations plans a program of action to assist all units of the Institute further in the broadening of its public relations and publicity in keeping with the high aims and objectives of the Institute. It is well known that a combination of sound policies and good practices, multiplied by effective, continuous publicity, produces good public relations. In discussing 1954 public relations plans it is intended to avoid getting lost in a fog of generalities and abstractions and to review the steps for the immediate future that will benefit in a practical way both the AIEE and the profession in regard to public relations.

CHARACTERISTICS OF A GOOD PROGRAM

ANY PROGRAM designed to develop and maintain good public relations for an organization cannot be static. It must be fluid, appraised in the light of changing conditions, and altered whenever necessary to meet these conditions.

Development of a good public relations program calls for team work and that has been forthcoming in the past from officers, committees, the headquarters staff, and above all from the Sections and Subsections and the key men and women who vitalize them.

As President Robertson has indicated, the importance of continuing progress based on science and technology—and the part the electrical engineering profession plays in it—are not known and understood well enough by the various publics. This lack of understanding of the functions of the electrical engineer and his contributions to the arts of pleasant modern life is a barrier not only to enhancing the prestige of the profession and the individual engineer, but may be a major reason why the younger generation is not excited about making it its profession. This is only one of the reasons why the AIEE public relations activities should keep pace realistically with other professions and vocations in this competitive world where people must be kept informed or they will not know about the importance of the engineer because of the complexity and speed of modern life.

We approach this task humbly, knowing that the ultimate goal is in the future. The spade work done by the committee so far only has tapped the possibilities. Much remains to be done. But it cannot be accomplished without concerted and continued effort and the co-operation of all electrical engineers. Public relations is not a garment to be put on or taken off at will, but should be permanent raiment for the profession and the electrical engineer.

Good public relations for a profession begins with its individual member. He is the one whose conduct and attitude sets the standard by which the public judges the worth and esteem of the profession. The electrical engineer who is a good citizen, participates in community activities, and has pride in his profession heightens not only his individual prestige, but that of electrical engineering.

But that is not enough. The public also must be kept informed constantly about electrical engineers and electrical engineering. The public is inclined to take both for granted. In the lives of most people, the electrical engineer and his profession have been here always, working quietly, performing modern miracles without fuss or fanfare. The electrical engineer is usually an unobtrusive fellow, a quiet person whose next-door neighbor probably has only a vague notion of the services he performs.

That is the task the Committee on Public Relations has set for itself. We want the public to know the electrical engineer and to understand what he does.

Full text of a special article recommended for publication by the AIEE Committee on Public Relations.

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Many engineers will say: "Why bother? I do my job, get paid reasonably well, so what do I care about what my neighbor, my community, or the world, for that matter, thinks about me and my work?"

My answer is that in an increasingly competitive world the public is important today. Ultimately its attitudes influence every person and every organization, profession, and business.

The opinion of the other man, who makes up the public, is highly important. Good public relations makes a difference in one's personal relationships, in one's job, and in one's profession. It is the difference in belonging to a highly respected group of men and women doing highly important work, or to a group thought of as hewers of wood and drawers of water.

SOME PLANS FOR THE FUTURE

During the next year the Institute's Committee on Public Relations plans to continue along the lines of the past few years, and to step up and broaden its program in an effort to reach as many publics as possible with the story of the electrical engineer and what he means to 20th century civilization. Newspaper publicity will be intensified; greater use will be made of radio and television on the national level; the careers of engineers who have made great contributions to the country will be published in the national magazines and the great feature syndicates. To use an analogy from our own profession, the Committee on Public Relations intends to act as a powerful radio station broadcasting the story of the electrical engineer and electrical engineering to all parts of the country.

But whatever efforts are made on the national level, ultimately the job of telling the nation about the electrical engineer and his works must be done at the local level, by the Section and Subsection publicity chairmen, just as the ultimate state of the engineer's relations with the public must be done by individual engineers.

Although the Institute has publicized its Winter General Meetings for many years in the past, in recent years it has broadened this program to include the other three General meetings, District meetings, the newsworthy affairs of the Institute, and has inaugurated and intensified public relations–publicity activities in the Sections and Subsections. To this end several issues of a Publicity Kit, incorporating publicity and public relations procedures and information, radio, television, and speech material, and skeletonized news stories, have been made available to Section publicity chairmen. A Publicity News Letter containing AIEE publicity news and procedural guidance was inaugurated 2 years ago, and a booklet on procedures for publicizing AIEE meetings was prepared.

In other words, the committee has attempted to alert the Sections to the public relations–publicity opportunities inherent in their profession and work, and not only has sought to stimulate them along these lines, but has tried to help them at the local level.

Co-operative services have been performed and aimed at encouraging Section publicity chairmen to publicize their activities in their local areas. It has assisted them to do it through use of newspapers, radio, and television, and to stimulate attendance at Section and Subsection meetings by making them more interesting and urging better attendance. Most of the 100 Sections now have active publicity committees that seek to keep their Section activities before the public.

Because General and District meetings are important, every effort has been made to assist the chairman in charge of publicity and his committee. The national Committee on Public Relations sees that they are furnished with publicity tools in the way of advance stories for the newspapers and radio; advance stories are sent to the national electrical and other trade magazines; all technical papers are screened for newsworthy items, which are sent to the trade press, the big news services, science writers, etc., and sufficient copies are mimeographed for use in the press room at the meeting. A staff member of our public relations representatives has been in attendance at each of the General meetings for the past 2 years, and at some of the District meetings, to give the local publicity chairman assistance with his local press, operation of the press room, and to help make photographic and radio and television arrangements.

Activities of the Institute also have been publicized, such as award of medals, changes in top personnel, policy changes, additions to membership, election of fellows, election of officers, and the like.

Another of the activities of the Institute, technical meetings throughout the country, has been publicized by means of advance stories in the newspapers and trade press.

As a result of the committee's efforts, there has been a definite awakening of interest in public relations and publicity throughout the Institute, a greater consciousness of the need for better relations with the various publics with whom the profession and the engineer deal.

REQUIREMENTS FOR SUCCESS

The Institute's thinking in regard to public relations is now in line with the electrical industry generally, particularly the utilities, many of which are now acutely aware of the need for presenting their side of the picture to the public.

It should be emphasized again that the success of any public relations program depends upon the individual members of the organization. No matter where an electrical engineer goes or what he does he is our representative for the profession. If he makes himself known in community activities, in technical presentations, in attendance at social functions, he is aiding our profession.

The electrical engineer knows himself how important his work is to the general public but now he should come forth and express his pride of profession to those outside his occupation.

The time for reticence is past and with the help of each member the wonderful story of electrical engineering can become as much a part of American life as the story of medicine and law.

If we all realize we are each ambassadors of electrical engineering then half our job is done for we are admitting that we have arrived, and that our profession is one of the most important in modern living.

Practical Aspects of Brush Stability

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ASSOCIATE MEMBER AIEE

THE CONTACT between a carbon brush and a revolving commutator is assumed in the accepted theories of commutation to occur over the total brush face and to be constant in position and length of circumferential arc. But this is not always so in practice. Under certain circumstances the contact area may shrink either from the entering or leaving edge of the brush or both with time, sometimes in days, sometimes in weeks.

If the circumferential arc shrinks, the interpole strength which was correct for full brush thickness becomes too weak for the new conditions and sparking develops.

If the circumferential arc changes, the contact center line of the brush changes, hence, compounding of a generator or speed of a motor is affected. Consideration of brush potential curves, obtained with both d-c and a-c voltmeters, confirmed that the arc could change in length, location, or both, with time.

These phenomena appear to be a function of brush or commutator surface or both as in every case the resurfacing of the brushes or the scouring of the commutator will give temporary relief.

Laboratory investigation with the aid of a cathode-ray oscilloscope incorporating special circuits to ensure perfect stability, free from extraneous influences and interference, have confirmed that under certain conditions the arc of contact changes. A high-resistance glaze can form at an edge of the brush contact surface and gradually extend until an appreciable reduction in the effective arc of contact, and perhaps a change in the location of its center line, can result.

The fact that this trouble is far from universal on large or high-speed machines is because a number of factors influence the degree of sensitivity to unstable arc of contact.

Machines with easy commutating conditions can tolerate variation of arc of contact without sparking or becoming unstable.

Reaction holders, particularly the 25° type, are more prone to this trouble than trailing holders. Pressure distribution over the brush face is far from uniform which leads to uneven current distribution, which aggravates the tendency for a local glaze to form.

A variable load causes such a variable current distribution that there is no possibility for any glaze forming on one portion of the contact surface.

One of the first methods used to combat variable arc of contact troubles was the use of open-textured electrographitic grades. These have a structure containing large interconnected pores. More intimate contact with the commutator is maintained and there is less tendency for a high-resistance glaze to form. It has been found that the more open the texture the less sensitive a grade is to arc of contact troubles. However, the earlier, very open textured grades had an unacceptably short life and the ultimate advantage in assistance to contact stability with these grades could not be utilized on account of this. Recently however, new techniques in the manufacture of open-textured grades have overcome this disadvantage to a considerable extent and have made it possible to go to greater lengths than ever before. It can be claimed that these new grades are almost entirely immune from arc of contact troubles.

A different line of approach to overcome contact instability is through the use of circumferential brush holder stagger. The way to accomplish this is to stagger or displace about half the brush holders on each arm forward in the direction of rotation of the commutator making sure that the amount of stagger is not exactly equal to the segment pitch.

This arrangement offers considerable advantage. In addition to reducing the tendency to arc of contact troubles, it makes the machine less sensitive to commutator irregularities by virtue of the fact that all the brushes on an arm are not disturbed simultaneously by an irregularity.

Even on a perfectly true commutator the brush is disturbed slightly by the passage of the slots between segments. Circumferential stagger reduces this effect because only half the brushes on an arm are disturbed at the same time by the arrival or departure of a slot. Obviously, to obtain this advantage the amount of stagger must not be exactly equal to the segment pitch.

These are improvements in collection but there is a further advantage in circumferential stagger in that the contact resistance at extreme entering and leaving edges is increased, thus giving considerable assistance to commutation.

Tandem holders wherein two brushes each with individual pressure fingers, separated by a partition and mounted one behind the other in one holder, are effective in preventing unstable arc of contact. It could be said the tandem holder carries the circumferential stagger to full thickness but the added advantage of assistance to commutation by entering and leaving edge resistance is absent.

Split brushes are used often when these troubles are encountered. Here the arrangement consists of two halves in a single holder without a dividing partition between them. A single pressure finger applies pressure to an extended pressure plate attached to one wafer and in turn the plate applies pressure to the remaining half. This method, though not as effective as the two aforementioned methods, is also quite effective in stabilizing the arc of contact.

Digest of paper 54-89, "Practical Aspects of Brush Stability," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, February 1954, pp. 44–8.

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A Radio-Relay Remote-Control System for FM Broadcast Stations

T. R. HUMPHREY

The Federal Communications Commission granted an experimental permit to the Rural Radio Network to operate two FM transmitters of its chain by remote control. Operators are informed continually of the stations' functioning which they control by dialing.

RURAL RADIO Network operates a chain of 13 FM stations on a radio-relay basis. Six of these stations are owned and operated by Rural Radio In common with most FM broadcast stations, the transmitters are located in mountainous terrain with relatively poor access, especially in the winter.

One site in particular, located at Bristol Center, N.Y., (about 30 miles south of Rochester) posed a serious enough access problem to warrant purchase of a special tractor-ski vehicle to provide transportation for personnel and supplies during winter months.

Although the economy which successful remote-control operation would afford was obvious, it was principally because of the hazard to personnel that the first investigations of the possibilities of remote operation were made.

In November 1949 Rural Radio Network petitioned the Federal Communications Commission (FCC) for special experimental authority to operate FM broadcast station *WVBT*, Bristol Center, N.Y., by remote control from FM broadcast station *WVCN*, DeRuyter, N.Y. These stations are approximately 80 miles apart.

The particular path was chosen for the initial experimentation both because of the extreme distance involved and because successful operation would minimize the personnel hazard at the remote station. Solution of the problems on the long path obviously would make extension of the system for shorter distances practical.

The FCC made a grant for such operation on an experimental basis in June 1950. In making the grant, the FCC emphasized that no reduction in equipment performance tolerances would be allowed. These requirements include: 1. Metering and maintenance of (*a*) power amplifier plate voltage, (*b*) power amplifier plate current, (*c*) r-f output voltage. 2. Observation of tower light condition. 3. Continuous monitoring of center-frequency deviation, modulation percentage, and aural condition of the transmitted signal. 4. Station identification announcements. These announcements must be made only on the carrier of the station identified.

In addition to these requirements, operational demands required metering and maintenance of a-c line voltages, due to exceedingly poor line voltage regulation in the rural transmitter location and control of an auxiliary power plant. Instantaneous selection of various relay receivers was necessary. Experience with the transmitters used, indicated that motor control of the power amplifier plate tuning and output link coupling adjustment was required.

Although the proposed remote control operation was the first granted by the FCC and there was no indication that permanent authority finally would be issued, it was decided to base design of the original equipment on the premise that the system eventually might be expanded to include more than one station. In practice, following adoption by the FCC of regulations authorizing remote control on a permanent basis, two remote stations are being operated from a single control point and work is in progress to incorporate two additional remote stations.

The broadcasting operations of Rural Radio Network depend on the retransmission of the programs received from adjacent stations. Consequently no wire circuits exist between stations. In some areas no wire facilities of any kind are available; therefore consideration was given only to control systems which would be applicable to the radio relay system used for normal broadcasting purposes. The expense of microwave equipment precluded its use for the remote control operation. Experience with multiplex facsimile transmission on the network had proved that tones in the ultrasonic range could be applied to the FM broadcast transmitters simultaneously with normal program material without deterioration of program quality.

An analysis of the functions to be performed showed them to fall into two categories: (1) those associated with the audio input requirements for normal program service for the remote station; specifically, selection of the proper relay receiver output and station identification announcements, and (2) those associated with the metering of the remote transmitter and the maintenance of operating constants by mechanical adjustment. The audio input selection function had to be independent of and not disturbed by interrogation or adjustment operations.

SELECTIVE DIAL SYSTEM

A DUAL dial system was chosen as the method to perform the job with a minimum of human error. One dial is used to select a specific bank. Dialing within the selected bank is performed by a second dial. With this system it is possible to select the bank assigned to receiver switching, using the first dial, and make the proper receiver selection on

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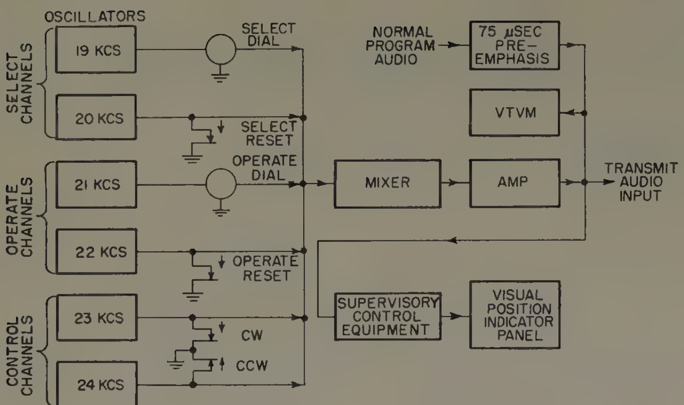

Fig. 1. Block diagram of control station generating equipment and supervisory control panel

the second dial; a bank assigned to telemetering then can be selected by the first dial and the desired telemetering position selected with the second dial.

Standard 10-position stepper relays were used. Six frequencies, equally spaced from 19 through 24 kc, were chosen. Fig. 1 shows a block diagram of the control equipment. The source tones are provided by six continuously running oscillators, the outputs of which are isolated from the keying circuits by conventional cathode-follower stages. The outputs of these stages normally are grounded through dials, push buttons, or keys. When the ground connection is removed from an individual channel by operation of the appropriate dial, reset push button, or control key, cathode-follower output is fed to the mixer stage and amplified. The amplifier output is bridged to the audio input terminals of the control station FM broadcast transmitter. The tone level is adjusted to modulate the FM carrier about 5 per cent, which corresponds to a level approximately 26 db below 100-per-cent modulation. Levels for each channel are equalized by gain controls located ahead of the mixer stage. Provision is made for pretransmission observation of tone levels.

To assist the control operator, a slave unit located at the control position is driven by the foregoing equipment. The slave is similar in design to the receiving equipment at the remote station. This unit serves several purposes. Its primary function is to operate a visual position indicator panel which shows the condition of the system at any given moment. Failure of any of the control equipment readily is shown on the panel which expedites the location of trouble. Network operation requires simultaneous receiver switching at all points. The slave unit stepper performs the receiver selection for the control station.

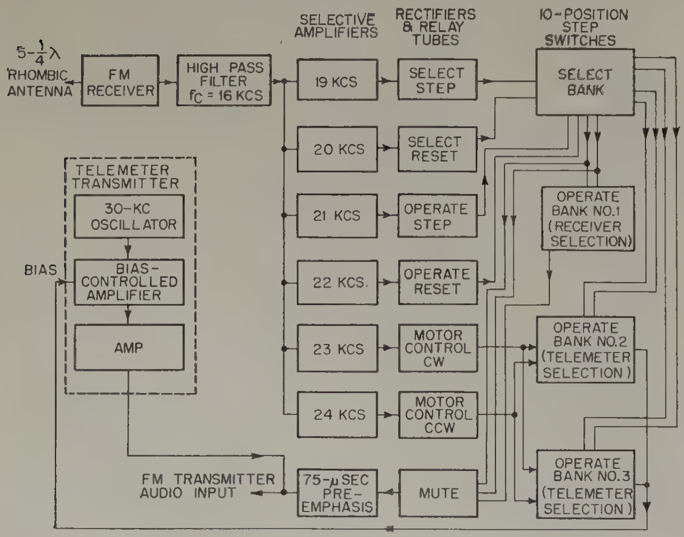
$5\text{-}\frac{1}{4}\lambda$ RHOMBIC ANTENNA
FM RECEIVER
HIGH PASS FILTER f_C = 16 KCS
SELECTIVE AMPLIFIERS
RECTIFIERS & RELAY TUBES
10-POSITION STEP SWITCHES
19 KCS
20 KCS
21 KCS
22 KCS.
23 KCS
24 KCS
SELECT STEP
SELECT RESET
OPERATE STEP
OPERATE RESET
MOTOR CONTROL CW
MOTOR CONTROL CCW
SELECT BANK
OPERATE BANK NO.1 (RECEIVER SELECTION)
OPERATE BANK NO.2 (TELEMETER SELECTION)
OPERATE BANK NO.3 (TELEMETER SELECTION)
TELEMETER TRANSMITTER
30-KC OSCILLATOR
BIAS
BIAS-CONTROLLED AMPLIFIER
AMP
FM TRANSMITTER AUDIO INPUT
75-µSEC PRE-EMPHASIS
MUTE

Fig. 2. Block diagram of remote terminal equipment

REMOTE TERMINAL EQUIPMENT

A block diagram of the remote terminal equipment is shown in Fig. 2. A crystal-controlled FM receiver tuned to the control-station frequency furnishes program material as well as the ultrasonic control tones. These tones are separated from program material at the discriminator output by a high-pass filter connected ahead of the conventional 75-microsecond de-emphasis network in the receiver. The tones are separated from one another by selective amplifier stages. The selectivity is provided by simple high-*Q* inductance-capacitance circuits adjusted to the desired channel frequency. The output of each channel amplifier is rectified and the derived positive direct voltage is applied as bias to a keyer tube which energizes a sensitive plate relay. The contacts of the sensitive relays are used to operate 10-position stepper relays or control the various motor functions.

One bank, or ten positions, is assigned to receiver selection and station identification announcement. Two banks, or 20 positions, are provided for telemetering interrogation and/or control functions. In the case of the receiver-selection bank, automatic reset is incorporated. When the tenth-stepper position is reached, the reset coil for the stepper is energized and the stepper returns to its off position. Simultaneously a time-delay circuit is triggered which initiates operation of a magnetic-tape playback machine. This machine, a product of Mohawk Business Machines Corporation, utilizes an endless tape. Station identification announcements are recorded on the tape. Conductive paint coatings placed at 10-second intervals stop the machine automatically through wiper contacts. The announcements are spaced within the 10-second intervals. Upon completion of the interval, the machine is in a condition to repeat the cycle. Identical installations are made at both the remote and control points. To make a station identification announcement on both stations, it is only necessary to dial a "0" in the receiver selection bank. The announcement is made for each station and the stepper is returned to its off position in preparation for the next receiver selection.

Since a number of receivers are fed to the receiver stepper switch, stepping or resetting the bank causes the stepper rotor contacts to pass over switch positions to which these "live" receiver outputs are connected. To avoid bursts of program material from undesired sources or the completion of feedback loops within the network system, electronic muting of the transmitter input is performed whenever a step or reset coil is energized in the receiver selection bank.

The telemetering steppers allow selection of sampling voltages at the remote point. The stepper contacts are interwired to allow meter observation during mechanical adjustment of pertinent controls. For example, power amplifier plate current can be observed in two positions of the stepper. In one case, this reading may be observed while the power amplifier plate tank is adjusted. The same reading is available while the output coupling link is adjusted mechanically. Only the mechanical adjustment directly affecting the meter position dialled can be performed.

The 19- and 20-kc channels, respectively, are used to step and reset the select stepper. This stepper, as the name implies, is used to select the desired bank in which an operation is to be performed. The 21- and 22-kc channels are used to step and reset the operate stepper. This stepper performs the desired operation within a selected bank and is controlled by a separate dial and reset push button. The 23- and 24-kc channels are used for motor control and on/off purposes and are transmitted by operation of a lever-type key.

As an example, assume it is wanted to measure power amplifier plate current and retune the plate tank of the power amplifier stage. Assume the power amplifier plate current-plate tank adjust position is position *4* in the third bank. First a 3 would be dialed on the select dial. This would transmit three pulses of 19-kc tone from the control station superimposed on the FM broadcast carrier. These pulses would be removed from the FM receiver at the remote point and separated as previously explained. The three pulses of 19-kc energy would be rectified and through the keyer tube advance the select stepper to its number *3* position. This presets the third bank for dialing within it. On the second dial at the control point, a 4 is dialed which transmits four pulses of 21-kc energy and in a manner similar to the foregoing, advances the stepper assigned to the third bank at the remote point into position *4*. Coincident with these stepper operations at the remote point it should be remembered that the visual position indicator panel at the control point is being keyed by the same signals so that at all times the control operator is aware of the operations he has performed.

When the stepper has reached the fourth position of the third bank as outlined, two circumstances exist due to interwiring. First the telemeter transmitter, details of which follow, is turned on and the appropriate sampling voltage applied to it for transmission back to the control point, and second, circuits are completed through interwiring to allow motor control of the power amplifier plate tuning control. At the control point, the motor control key is thrown either to the left or right and the correct motor at the remote point will be energized as long as the key is depressed. Power amplifier plate current is observed during this tuning period and the desired effect can be achieved.

RETURNING OPERATIONAL INFORMATION

TELEMETERING information is returned to the control point by superimposition of a 30-kc tone on the carrier of the remote FM broadcast transmitter in a manner identical to that used to transmit the tones from the control transmitter. The telemeter transmitter (see Fig. 2) consists of an oscillator driving a variable gain amplifier. The output of the amplifier stage is proportional to the value of sampling voltage applied as grid bias to the stage. The standard reference voltage used for circuit calibration is furnished by a 12-volt "hot-shot" battery. Voltages for normal operating values are derived from the various sources which are telemetered and are compared to the reference voltage. Telemeter output level is adjusted to modulate the remote FM broadcast transmitter 5 per cent when standard reference voltage or normal sampling voltage is applied as bias.

At the control point the 30-kc voltage is separated from normal program material at the discriminator output from the General Electric (GE) *BM-1-A* Station Monitor. The telemetering voltage is removed by filtering and feeding through a selective amplifier. The output voltage of the selective amplifier is measured on a conventional broadcast-type *VU* meter, for which direct-reading scales have been prepared to indicate r-f output voltage, power amplifier plate voltage, power amplifier plate current, and a-c line voltage. In the region of normal operating values these scales are greatly expanded. This effect provides closer tolerances at the control point than are possible at the remote point on standard meter scales.

It is of course essential that the control station maintain full control of the remote station under all conditions. To assure maintenance of this condition the filament circuits of the remote transmitter are interlocked with a carrier-operated relay circuit operated by second limiter grid voltage in the FM relay control receiver. Failure of the control station, the control receiver at the remote point, or of any of the tubes in the filament control circuit automatically removes the remote transmitter from the air. In addition, a limit control was incorporated which operates on variations in field intensity of the control station signal at the remote point. This control is adjusted to remove the remote carrier from the air, if due to propagation effects the control carrier should drop below a prescribed level. This avoids the possibility of capture of the remote transmitter by another station operating on the control-station frequency and whose signal might be receivable during unusual propagation periods. Discrimination against undesired signals is abetted further by the use of a multi-wavelength terminated rhombic receiving antenna at the remote point. This antenna was designed for maximum front-to-back ratio rather than maximum forward gain. Over a period of 18 months, during periods of extreme propagation variations, no difficulties have been encountered on this score.

In fulfilling FCC requirements relative to center-frequency deviation and modulation percentage, it was deemed highly preferable to utilize equipment which carried FCC approval rather than to become involved in any system which would require FCC type of approval before being acceptable. As a result the dual conversion system shown in Fig. 3 was used.

THE DUAL CONVERSION SYSTEM

THE REMOTE station operates on 95.1 mc (f_1), see Fig. 3. The GE Type *BM-1-A* Station Monitor used was calibrated for a frequency of 107.7 mc, a difference of 12.6 mc (f_2). A temperature-controlled crystal oscillator operating on this difference frequency is the source for oscillator injection

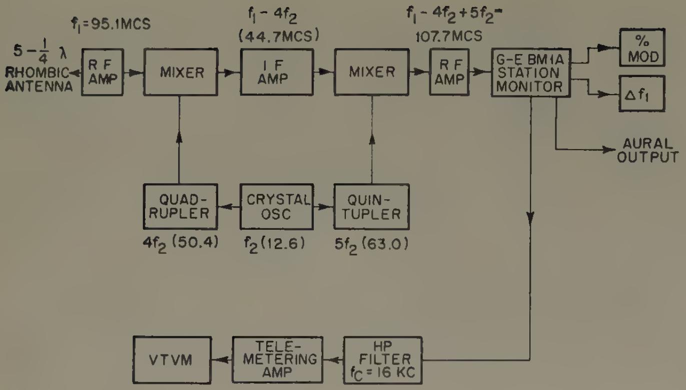

Fig. 3. Block diagram of dual conversion monitor driver unit and telemetering receiving unit

voltages for the dual conversion. Adjacent harmonics, the fourth and fifth ($4f_2$ and $5f_2$), are used for injection frequencies. The fourth harmonic, 50.4 mc, beat against the 95.1-mc signal frequency in the first mixer produces a difference intermediate frequency of 44.7 mc. This frequency, when heterodyned with the fifth harmonic of the difference oscillator on 63.0 mc, produces a sum beat of 107.7 mc, the frequency for which the GE approved monitor was calibrated. With this system, three frequencies are available at which considerable amplification can be had without interaction: the signal frequency of 95.1 mc, the intermediate frequency of 44.7 mc, and the output frequency of 107.7 mc. Adequate gain is provided to supply the watt or so of r-f power required to drive the GE monitor. The monitor provides direct-reading values of center-frequency deviation and modulation percentage. In addition, the monitor is used as the source at the control from which the telemetering voltage is derived and from which aural monitoring is fed.

In the conversion system described, the accuracy of the unit depends upon the tolerance of the difference-frequency oscillator. The frequency of this oscillator is checked periodically against *WWV* transmissions, using a secondary standard for interpolation. In practice, the stability of this oscillator is excellent enough so that in view of the ± 2,000-cycle-per-second frequency tolerance required at the operating frequency, the error in actual transmitter frequency, indicated by the GE monitor, is slight.

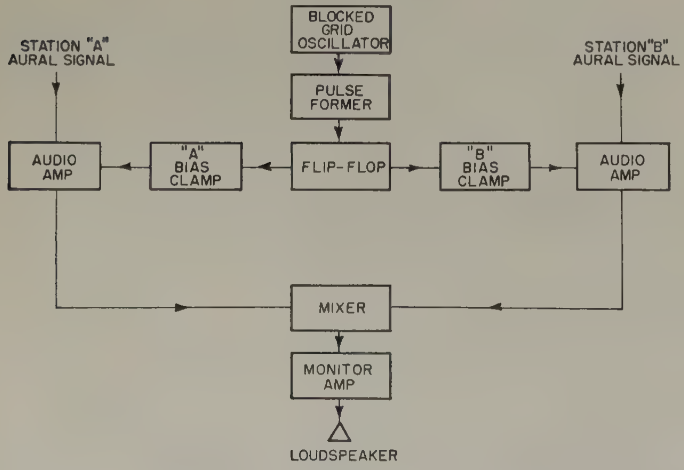

Fig. 4. Block diagram of electronic switching arrangement for aural monitoring of control and remote stations

STATION IDENTIFICATION

THE VARIOUS stations of Rural Radio Network carry identical program material with the exception of station identification announcements. Although it would be possible to furnish separate monitoring facilities for the control and remote station, loss of one station might not be immediately apparent to the operator on duty. Deterioration of program quality would be masked by the loudspeaker signal of the other signal. To make loss of or deterioration of either signal readily apparent, the automatic monitor switching method shown in Fig. 4 was devised.

A low-frequency blocked-grid oscillator furnishes the switching-rate time base. The sawtooth output is formed and fed to a conventional "flip-flop" circuit. To each half of the flip-flop circuit, are connected clamp keyer tubes. These are sharp-cutoff pentodes, the cathode returns of which are made through the cathode bias resistors of medium-mu triode audio-amplifier stages. Constants are such that when the clamp-tube cathode current is maximum, adequate voltage appears across the triode audio-amplifier cathode resistor to cut off this stage completely. Consequently, one audio channel is operative while the other is biased to cutoff. The outputs of the two channels are mixed and fed to a common monitoring amplifier and loudspeaker. Thus, although the output signal is continuous, it is composed of equal segments from each station's program. Loss or deterioration of either signal is immediately apparent to the control operator. A sampling rate of about one sample each 6 seconds is found to be satisfactory.

Although a change in transmitter power with a resultant shakedown period interferes with a precise analysis of the reliability of the remote control system, such an analysis was made. This was based on identical 4-month periods, before and after remote operation was installed. A percentage of performance figure showed a reduction of 0.35 per cent. This period also involves the earliest period during which unattended operation was begun and represents the poorest records on hand. Improvements in equipment design and development of maintenance techniques constantly have improved the reliability.

Difficulty has been experienced with intermittent false stepping of the receiver selection bank, due apparently to transients in "live" speech programs. Oddly enough, no trouble of this sort has been encountered with musical programs where difficulty was anticipated from harmonic generation. The difficulty seems to be sporadic and is confined to a specific program and one individual. Although considerable time has been devoted to observation of selective amplifier outputs during these programs, to date nothing concrete has been isolated. New gating circuits are being incorporated to eliminate this trouble. A 29-kc tone, amplitude modulated by a 500-cycle signal, will be transmitted prior to any of the operational tones. The gate envelope is demodulated and the derived 500-cycle signal is used to control the main relay supply source. Bench tests indicate that this will cure the trouble completely.

Nuclear Power Plants for Ship Propulsion

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Two prototype submarine atomic power plants are being developed: the Submarine Thermal Reactor and the Submarine Intermediate Reactor. Their fundamentals are discussed as are those of a gas-cooled reactor power plant.

SHIP PROPULSION appears to be the earliest practical application for a mobile atomic power plant and consideration of some fundamentals of a nuclear power plant will make the reasons apparent. As conceived today, a nuclear power plant differs from a conventional plant mainly in the method of heat production and heat transfer to a thermodynamic fluid, which is expanded in turbomachinery to produce power in the conventional way. In a plant using steam as the thermodynamic fluid, the nuclear reactor and steam generation equipment will replace the boiler and its accessories. Although the reactor core itself can be of relatively small dimensions, the shielding required around it increases the over-all volume and weight of a reactor by a considerable factor. Furthermore, the reactor coolant and heat transfer fluid is made radioactive in passing through the reactor and all of the machinery through which it flows must be shielded. The shielding around the reactor core proper is called the primary shield, and the shield around the heat transfer equipment, the secondary shield.

As the amount of shielding is practically independent of power output, a nuclear power plant of low power will be penalized excessively with respect to its power output. As the power output of a reactor–steam generation plant is increased, the equipment volume and shielding around it does not increase in direct proportion to the power; hence, a more favorable relationship is reached between power output and plant space and weight. Power plants for propulsion of larger power ocean-going vessels (of the order of 10,000 hp and above) are of sufficiently large power output to fall within the favorable range for a nuclear power plant of current design.

Nuclear power is singularly advantageous in a submarine. Freed from dependence on the atmosphere for combustion air, the submarine becomes a true undersea craft—not just a surface ship that is able to submerge when required. This particular advantage has led to the very extensive development programs now in progress on atomic power plants for submarines, under the combined direction of the Atomic Energy Commission and United States Navy. Two prototype submarine power plants are being developed: (1) the Submarine Thermal Reactor (STR) which is in operation at the National Reactor Testing Station at Arco, Idaho, and (2) the Submarine Intermediate Reactor (SIR) now under construction at West Milton, N. Y. Although these particular power plants are for submarine application, much of the technology and experience accumulated in the course of their development is applicable to power plants for ship propulsion in general. From examination of the fundamental characteristics of these plants, it is possible to visualize their applicability to general ship propulsion.

SODIUM- AND WATER-COOLED REACTOR POWER PLANTS

BOTH the STR and SIR plants include the same basic components indicated in Fig. 1. Heat is generated in the reactor, transferred to a heat-transfer fluid which carries the heat to a steam generator, where the heat is transferred to steam. The basic difference between these plants is the reactor coolant or heat-transfer fluid which is a major factor in establishing the characteristics of all the equipment through which it flows. In the STR plant pressurized water is the heat-transfer fluid, whereas in the SIR plant liquid sodium is used. The reactor cooling water in STR is maintained under sufficient pressure to prevent boiling in the reactor core.

The coolant has a significant effect on reactor characteristics which are dependent upon the energy of the majority of neutrons initiating fission. Neutrons are ejected from fission with high kinetic energy and the average neutron energy in a reactor core can be established by selection of material. Light materials like hydrogen and carbon slow down or moderate neutrons by billiard-ball-like collision of neutrons with their nuclei. Water is a

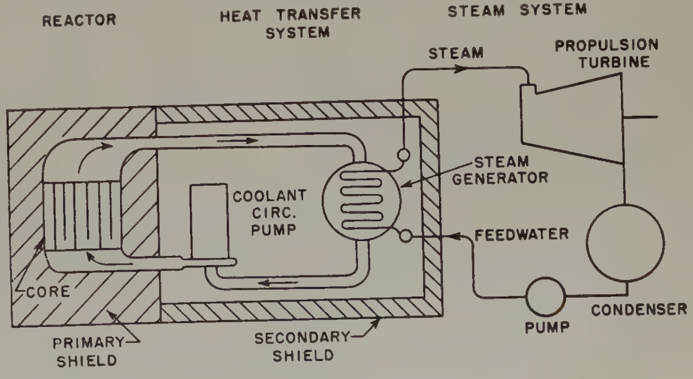

Fig. 1. Schematic diagram of a nuclear power plant

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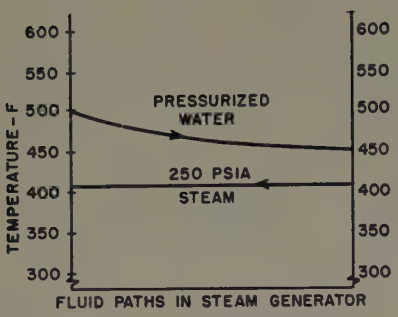

Fig. 2. Temperature-fluid path diagram for steam generator heated with pressurized water

good moderating material, and in STR it performs the double duty of reactor cooling and neutron moderation. In this reactor the neutrons are slowed down to their normal or thermal energy level before initiating fission, hence the name thermal reactor.

Sodium is a weak moderating material, and it is advantageous to operate a sodium-cooled reactor at an energy level higher than thermal. Moderation to the selected energy level is obtained by incorporating an additional moderating material. The SIR reactor operates in the intermediate neutron energy range, that is, higher than thermal energy but below the high-energy level of neutrons ejected from fission.

There are various advantages and disadvantages associated with each reactor type. The investment of fissionable material is less for a thermal reactor but at this energy level certain reactor poisons have a stronger effect on the reactor requiring additional provisions for control. At higher energy a wider choice of reactor structural materials is available. More detailed comparison of nuclear characteristics is not permitted by security restrictions. Later discussion, however, will cover other aspects of the relationship between the reactor and coolant.

THERMODYNAMICS AND HEAT TRANSFER

ANOTHER significant difference between the plants is in their heat transfer and thermodynamic aspects. For submarine application minimum plant size and weight are required and the selection of operating conditions for each plant is made towards this objective. Although aimed at the same objective, this selection is affected by different factors in each plant. The STR plant is considered first.

In the STR reactor the water coolant is maintained in the liquid state by pressurization of the primary coolant system. Examination of the steam tables shows that to maintain water in the liquid state at elevated temperature requires high system pressure. The saturation pressure at 500 F is 681 pounds per square inch absolute, at 600 F is 1,545 pounds per square inch absolute. This high system pressure is a characteristic of a water-cooled power reactor system. It is also one of the factors in establishing the maximum operating temperature of the reactor and heat transfer system.

To attain the high rate of heat transfer desirable in the reactor, a high water velocity is required in the cooling passages. The passage size is reduced to a practical minimum and the water flow rate set to provide the desired velocity. The relatively large flow rate thus established and the high specific heat of water at elevated temperature (approximately 1.2 Btu/pound-F at 500 F) result in a low-temperature rise of the coolant in passing through the reactor. Fortunately these conditions are compatible with the thermodynamic requirements of the plant. As the maximum temperature of the water is limited by pressure and other factors, it is desirable to maintain the minimum possible temperature difference in the primary circuit to permit the best possible steam conditions. This can be made clearer by reference to Fig. 2. In this example, 500 F is arbitrarily chosen as the bulk water temperature at the reactor outlet and a 50 F temperature difference is assumed in the primary circuit. Two factors affect the selection of steam pressure for these primary coolant conditions:

1. The highest steam pressure is desired for best heat rate and smallest steam piping and turbine size.
2. To the extent that heat transfer area rather than steam volume flow establishes the size of the evaporator, it is desirable to reduce steam pressure to provide a larger mean temperature difference between the primary water and the steam.

In lowering the steam pressure, a point is reached where the steam volume flow establishes the size of the evaporator. At best the steam pressure for a water-cooled reactor plant is low by current standards. Furthermore, since a relatively low mean temperature difference exists between the primary water and the steam saturation temperature, the small degree of superheating available is not particularly advantageous. The net value of adding a superheater which needs to be shielded versus using saturated steam in the turbines is dependent upon the specific application. When saturated steam is used, provision is required for removal of moisture in the low-pressure turbine stages.

In a sodium plant the maximum sodium temperature is not limited by system pressure, as the boiling point of sodium is approximately 1,600 F at atmospheric pressure. It appears that the strength of materials is likely to be the limitation upon maximum temperature. Furthermore, sodium heat-transfer coefficients are adequate at moderate sodium velocity. The area of the cooling channels still must be reduced to the practical minimum, however, to reduce the absorption of neutrons by sodium and to provide space for moderating material. As the specific heat of sodium is relatively low (approximately one quarter of high-pressure water) either the flow rate or temperature difference or both must be pushed to the limit to remove the heat transferred into the passages. As a high coolant flow rate requires large external piping or high pressure drop, the sodium temperature difference is increased to the practical maximum. A high coolant temperature difference appears to be characteristic of a sodium-cooled reactor. One effect of this relatively high temperature difference is to require greater emphasis on thermal stresses in design of the reactor and heat-transfer equipment than is required in conventional power equipment. In some instances, thermal stresses become the major factor limiting design.

A typical set of sodium conditions was selected for test in the first power plant scale developmental system of the Knolls Atomic Power Laboratory.[1] These conditions are shown in Fig. 3. The higher sodium temperature difference, as represented by the steep slope of the sodium line, makes superheating desirable if only to reduce the large temperature difference between the incoming sodium and the outlet steam in the evaporator unit. The higher average temperature of the sodium permits the use of steam conditions more nearly standard, but still somewhat outmoded by present-day practice. The selection of boiler pressure is a compromise between favoring the evaporator with a large mean temperature difference or favoring the turbine and steam piping and auxiliaries by selecting the highest possible pressure.

A very significant difference exists in the radioactivity induced in the coolant by the neutron flux in the reactor. Radioactive sodium emits a more intense radiation and the decay period for its radioactivity is considerably longer. The greater intensity of secondary radiation requires a greater thickness of secondary shield. To make the two plants competitive in weight it is necessary to make the volume of sodium equipment to be shielded smaller to compensate for the additional shield thickness. In the SIR plant shielding accounts for over 35 per cent of the total weight, whereas in STR shielding amounts to less than 30 per cent. The longer decay period of sodium activity results in a significantly longer waiting period for the radioactivity to die off before access is possible within the secondary shield.

HEAT TRANSFER SYSTEM AND AUXILIARIES

THE DIFFERENCE in chemical activity of the two coolants is well known. Sodium burns in air and reacts violently with water, requiring special provisions in system design and handling. It should be noted, however, that the radioactivity of both coolants dictates the need for systems of a high degree of leak tightness. The consequences of a sodium leak are apt to be complicated by chemical reactions unless additional precautions are taken. Some of these precautions are described in technical literature.[1,2] In the steam generator where sodium and water would contact in event of a leak, a double barrier is provided between them. Double tubes and tube sheets are used and a leak-detection system is provided to monitor the space between them. These precautions reduce to a minimum the chance for a sodium-water reaction. Sodium leaking out of the system piping or equipment can be kept from burning by maintaining an inert atmosphere around the entire heat-transfer system and its components.

The technique for coolant purification in both plants is different. Control of water conditions to prevent corrosion is the subject of some controversy and each school has good reasons to substantiate its method. Common to all, however, is the need for continuous control of the specific water conditions either by purification or by additives. With sodium it is possible to clean the system originally and purify the initial charge to an acceptable state and then operate with a sealed system without constant repurification. Occasional batch repurification is required depending upon the extent of contamination during maintenance operations.[2] It is interesting to compare the extent to which oxygen is tolerated in sodium and in boiler feed water. From the standpoint of corrosion, 100 parts per million sodium oxide in sodium is acceptable. Deaerating feed heaters are required to reduce oxygen to 0.005 cubic centimeter per liter, which is equivalent to approximately 0.007 part per million by weight.

The function of system pressurization is different in the two plants. The pressure of the primary water system must be controlled continuously during operation, between the maximum relief pressure and the minimum permissible to retard boiling in the reactor. With sodium, an inert gas atmosphere is charged into the system at a nominal initial pressure and sealed. During operation the gas pressure varies with average system temperature.

A function common to both plants not encountered in a conventional plant is the requirement to provide reactor cooling after nuclear power operation is stopped. Radioactive decay of fission products in the reactor core produces heat which must be removed to prevent overheating of the core. This is an absolute requirement which must be met even under emergency conditions such as loss of ship's power.

A requirement peculiar to sodium alone is the provision for heating of all parts of the system to maintain the sodium in its liquid state during filling and when reactor heat is not available. Sodium melts at 210 F and external heating must be provided up to about 250 to 300 F to assure complete melting in all parts of the system. Provision for electric heating is not difficult but represents an additional complication of the primary coolant system.

ELECTRIC SYSTEM

IN ADDITION to supplying the special electrical demands of the submarine, the electric system for both plants provides power for ship service and power-plant auxiliaries similar to conventional marine practice. Where in the conventional plant, power is required for boiler fans, in the nuclear plant, power for primary coolant pumping represents a similar load. The power requirements for coolant pumping are larger and of a somewhat more specialized nature. In the SIR plant, for example, a-c electromagnetic pumps of the induction type are used for primary coolant pumping. The characteristics of this type of pump are described in technical literature.[3] For

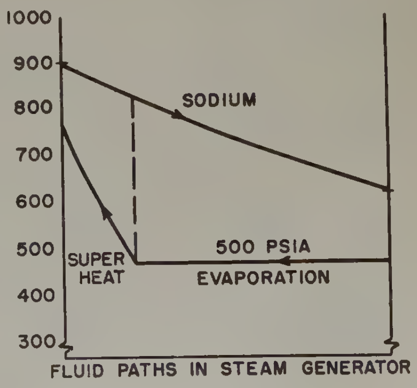

Fig. 3. Temperature-fluid path diagram for steam generator heated with liquid sodium

Table I. Comparison of Different Gases for the AK-Process

Gas	Air	He+CO_2	He+CO_2	He	H_2	
Mean molecular weight	29	8	6	4	2	
Specific heat, Btu (lb) (deg F)	0.26	0.755	0.90	1.25	3.5	
Ratio of viscosity (T = const)	1	1	1	1	0.5	
Ratio of sound velocity	1	2.1	2.4	3	3.9	
Adiabatic pressure ratio for temperature ratio	4	2.92	2.71	2.52	3.65	
Turbine and Compressor						
Number of stages (ratio)	1	2.8	3.5	4.8	13.5	For constant circumferential velocity
Circumferential velocity	1	1.75	1.9	2.2	3.7	Constant number of stages
Diameter (ratio)	1	0.76	0.73	0.68	0.52	
Revolutions per min	1	2.30	2.6	3.3	7.1	
Heat Exchanger						
Coefficient of heat transmission	1	1.86	2.12	2.56	4.35	
Number of tubes	1	0.66	0.62	0.56	0.27	(Ratio)
Lengths of tubes	1	0.82	0.76	0.70	0.85	
Surface area of tubes (weight)	1	0.54	0.47	0.30	0.23	
Heaters						
Coefficient of heat transmission	1	1.6	1.7	2.0	4.0	(On one side)
Number of tubes	1	0.78	0.75	0.68	0.30	
Length of tubes	1	0.82	0.79	0.74	0.85	
Surface area of tubes (weight)	1	0.64	0.59	0.50	0.25	(Ratio)

this discussion it is sufficient to state that the output of the pump is a smooth function of input voltage. This suggests a convenient method of flow control by variation of input voltage, either by providing a separate a-c generator with field control or by means of an induction voltage regulator from the bus. A specially controlled power supply, based on frequency variation, is provided for the STR primary coolant pumps.

A special problem is encountered in electrical insulation of primary coolant pumps, as the coolants are radioactive and at relatively high temperature. Both conditions are aggravated in the sodium pump which must handle a higher temperature fluid and is subjected to radiation of higher intensity. Extensive tests have been performed on insulating materials to evaluate their suitability under operating conditions. Liquid cooling has been incorporated into both pumps to maintain acceptable insulation temperature. In the sodium pump, highly effective thermal insulation is used to reduce heat transfer from the sodium duct to the field windings.

The combination of temperature and radiation encountered in the vicinity of the sodium piping system requires the use of special cable of the copper-sheathed mineral-insulated type. Ceramic end seals for this type of cable have been developed at the Knolls Atomic Power Laboratory for this application.

SUMMARY

SOME GENERALIZATIONS can be drawn from the foregoing comparison. The water-cooled reactor plant is characterized by:

(*a*). Thermal reactor.

(*b*). High pressure in primary system requiring continuous control of pressure level.

(*c*). Relatively low reactor operating temperature and temperature difference.

(*d*). Low-pressure steam, possibly no superheat.

(*e*). Continuous control of water chemistry.

(*f*). Lower level of coolant radioactivity and shorter decay time.

The sodium-cooled reactor plant is characterized by:

(*a*). Reactor of higher than thermal energy.

(*b*). Low pressure in primary system—no pressure control required.

(*c*). Relatively high reactor operating temperature and large temperature difference making thermal stresses significant in design considerations.

(*d*). Moderate conditions of steam pressure and superheat.

(*e*). Occasional batch sodium repurification required depending upon contamination during maintenance operations.

(*f*). Higher level of coolant radioactivity and significantly longer decay time.

(*g*). External preheating required to melt sodium prior to reactor operation.

GAS-COOLED REACTOR POWER PLANT

PRELIMINARY studies have been made of a power plant incorporating a gas-cooled reactor coupled to a closed-cycle gas turbine system. Helium was selected as the working fluid mainly because it does not become radioactive and requires no secondary shielding provided it can be maintained free of impurities and foreign material. As the secondary shield is an appreciable portion of the total plant weight, its elimination or reduction by a significant amount is highly desirable. Absence or reduction of secondary shielding also permits greater flexibility of machinery arrangement and possibly closer packing of components.

Helium possesses good heat transfer properties in the pressurized state. A comparison of gas properties for closed-cycle gas-turbine systems is shown in Table I. Relative to other gases, helium has a high specific heat and yields high heat transfer coefficients. A disadvantage of helium is that it requires a larger number of turbine and compressor stages than a heavier gas like nitrogen or air.

Thermodynamic cycle studies were made to evaluate simple, intercooled, regenerative, and combination cycles. At first thought it might appear that with nuclear fuel, efficiency could be sacrificed to obtain plant simplicity and small size and weight. This might be done to a limited extent; however, it appears that intercooling and regeneration are required to establish acceptable temperature differences across the reactor and precooler and to

Table II. Comparison of Power Plant Characteristics

Reactor Coolant	Water	Sodium	Helium
Shaft power output	0.90	1	1
Over-all plant weight	0.97	1	0.64
Specific weight lbs/shp	1.08	1	0.64
Space occupied c.f./shp	1.10	1	0.66
Shield weight	0.77	1	0.51

reduce the rate of helium flow. Both effects simplify the reactor design, which appears to be difficult under the best possible conditions. For the intercooled and regenerative cycle, with the component efficiencies and pressure drops assumed, the minimum heat rate occurs at a pressure ratio between $2^1/_2$ and 3, and the minimum helium rate between 3 and 4 depending upon peak cycle temperature.

A schematic diagram of the cycle is shown in Fig. 4. The basic cycle includes compressor intercooling and regeneration for the reasons mentioned earlier. In the arrangement shown, the high-pressure turbines power the two stages of compression, while the low-pressure turbines supply output power. Not shown is a reversible-pitch propeller which is required for astern drive. Auxiliary equipment, circled on the diagram, includes a starting motor, auxiliary power turbogenerator set, and provision for output control by varying system density. In this particular arrangement a simple-cycle gas-turbine unit is provided to remove reactor decay heat in event of failure of the main power plant.

The design peak cycle temperature for this study is conservative in comparison to current stationary gas-turbine practice as the reactor design conditions are limiting. The maximum system pressure is somewhat in excess of 1,000 pounds per square inch. It is a compromise between establishing maximum gas density for minimum equipment volume and setting an acceptable wall thickness for the larger diameter vessels. The component efficiencies assumed are based on current best practice in gas-turbine machinery.

Preliminary designs and outlines of equipment were prepared and a machinery arrangement study was made for a submarine power plant. Some characteristics of this plant are indicated in Table II compared to sodium-cooled and water-cooled reactor plants designed to meet the same objectives. This comparison indicates possible superior performance for the helium plant. It must be emphasized, however, that the helium plant studied is based upon availability of an extremely high-temperature reactor fuel-element material and upon the assumption that no secondary shielding is required. A great deal of development work is required to establish these and other assumed factors experimentally. Furthermore a power plant usually suffers deterioration in performance, size, and weight as it proceeds into detail design and more of the detailed operating requirements become apparent. These factors must be taken into consideration in comparing characteristics of these power plants.

CONCLUSION

THE PRESSURIZED-WATER and liquid-sodium cooled reactor plants can be considered in an advanced stage of development for the relatively short period of time from their inception. From the long-range point of view, however, they represent a first step towards reactor and power plants of simpler configuration and improved performance.

Although the power plants described have been designed for submarine application, much of the basic technology involved is useful for other applications. Successful operation of the first two plants now under development undoubtedly will open the way for other marine applications of atomic power plants.

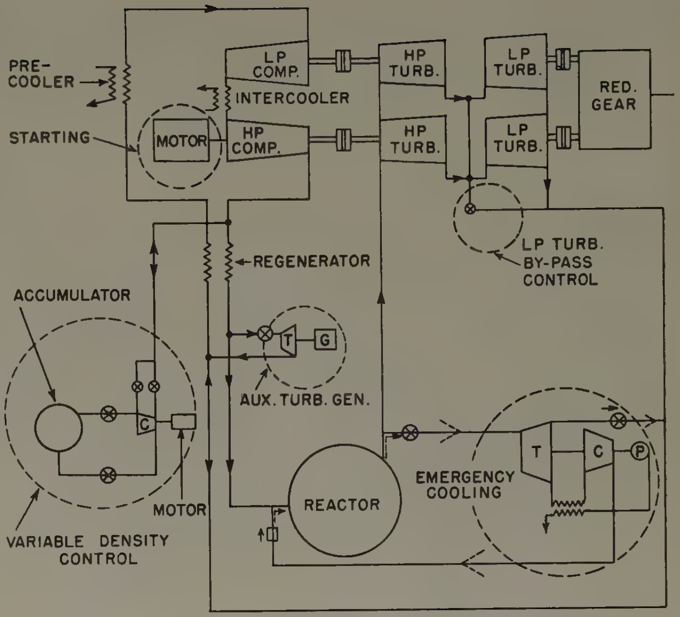

Fig. 4. Schematic diagram of a gas-cooled reactor plant

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Report on Color Transcriptions

A technical report on "Color Transcriptions," expected to arouse widespread interest in the television and motion picture industries, has been made available in printed form by one of the technical panels of the National Television System Committee (NTSC), it has been announced.

Dr. Alfred N. Goldsmith of New York, N. Y., chairman of NTSC panel *11-A*, which probed "Color Transcriptions," reported that acceptable color-film records of live programs and color release prints suitable for color television transmission can be produced and satisfactorily transmitted by available materials.

Dr. Goldsmith described the panel report as "the first handbook on color transcriptions, their projection and use, from a technical and industrial viewpoint."

Copies of the report are available to producers and processors of color television film, networks or stations planning use of color transcriptions, laboratories producing color film or color film equipment, through the office of NTSC Chairman W. R. G. Baker, General Electric Company, Electronics Park, Syracuse 1, N. Y.

Single-Core Magnetic Amplifier Analysis

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A REVIEW OF THE literature concerned with magnetic amplifiers has revealed a multitude of articles dealing with the load circuit and sometimes control circuit response of single-core amplifiers employing the self-saturation principle. These discussions all have utilized specific assumptions which in each case were aimed toward an ultimate simplification of the mathematical manipulations directed toward the solution of the required response. In some cases the assumptions are valid; however, the general case of magnetic amplifier operation often suffers because of the specializations thus used. It therefore seems worth while to consider a rigorous mathematical analysis based upon the existence of finite forward and reverse rectifier resistances as well as a flux-current loop of finite area and finite slope.

The fundamental single-core circuit is shown in Fig. 1. A control circuit is not included with the core since in the present consideration the objective is to develop the load circuit relationships which will indicate the dependency of the load current on the rectification ratio and core constants.

The core magnetization function is shown in Fig. 2. The restrictions here imposed are those of infinite slope when $\phi = \phi_S$, and infinite slope when $\phi = \phi_n$. Since the sides of the magnetization function are taken to be linear, it is possible to write

$$g(\phi)=N_1 i=S\phi\pm h_0,\ i=\left[\frac{S\phi}{N_1}\pm\frac{h_0}{N_1}\right]$$

If the applied voltage is given by $e_1 = E_m \cos \omega t$ then the differential equation for the circuit becomes

$$E_m \cos \omega t=iR_T+N_1\frac{d\phi}{dt}\times 10^{-8} \text{ volts}$$

Here the quantity R_T includes the total circuit resistance during the given time interval of consideration.

From the foregoing differential equation and instantaneous current relationships the following quantities will be obtained in view of their importance for appropriately describing the action of the circuit:

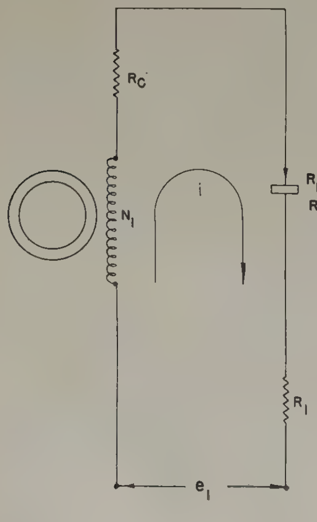
1. Firing time (t_3) as a function of circuit parameters.
2. Time (t_5) when the core leaves saturation.
3. Time (t_6) when the rectifier leaves forward conduction.
4. Magnitude of negative flux swing.
5. Instantaneous current functions for the complete cycle.
6. Average current for a cycle.

In deriving the solution of the differential equation for the various intervals over the complete cycle, it is observed that the magnitudes of the core constants ϕ_R, ϕ_S, h_0, and S are important factors in determining the boundary angles for the cycle of core operation. Similarly, the rectifier forward and back resistances are important factors in determining the same boundary angles. An example of this dependence exists in the angle (ωt_5) which represents the angle in the input cycle where the core leaves saturation. It is shown that

$$\cos \omega t_5=\frac{R_{TF}}{E_m}\times\frac{h_0}{N_1}\times\left(\frac{\phi_S}{\phi_R}-1\right)=\frac{R_{TF}}{\dfrac{\omega N_1^2}{S}\times 10^{-8}}\times\left(1-\frac{\phi_R}{\phi_S}\right)$$

The factor $R_{TF}/\left(\dfrac{\omega n_1^2}{S}\right)\times 10^{-8}$ is a factor whose general form occurs throughout the development. It is seen readily that it is of the form of $({}^1/_Q)$ where Q is the quality of the circuit. When the reactance factor $\omega N_1^2/S \times 10^{-8}$ is large in comparison to the total forward resistance of the load circuit, then (ωt_5) is very close to $\pi/2$ even if $\phi_R << \phi_S$.

The importance of the magnitude of rectifier back-to-front ratio for a core material, whose constants are known is shown in order that in a practical case the proper core material and load turns may be chosen for a given rectifier, or conversely, in order that the material may be utilized in the region of greatest signal sensitivity.



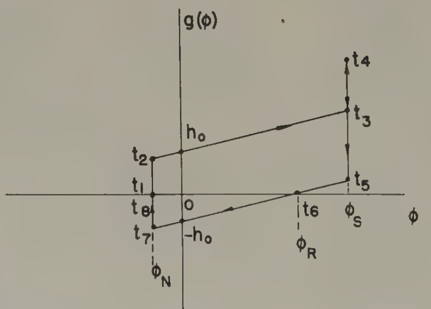


Fig. 1. (left) Fundamental amplifier

Fig. 2. (above) Magnetization function

Digest of paper 54-158, "Analysis of a Single-Core Magnetic Amplifier With Real Rectifier and Core Functions," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Line Amplifiers for Community Television Systems

K. A. SIMONS DON KIRK H. J. ARBEITER

The various factors affecting the choice between the three basic types of amplifier suitable for line amplifiers in community television systems are discussed. The data clearly favor use of the single-channel amplifier, and increasingly so as the system is extended. However, the increased economy of the cascade broad-band types makes it preferable on small systems with short cable runs and few repeaters.

SINCE the first successful community television system was installed in May of 1950 at Lansford, Pa., this infant industry has come a long way. At this writing there are some 240 systems providing television reception to a potential audience of several hundred thousand people in the U. S.

This mushroom growth has brought with it the development of many new techniques, and the need for solving a multitude of technical problems. Although some of the art is entirely new, the basic technique of moving television frequency signals efficiently from one place to another is closely allied with long-distance telephony.

The possibility of a community television system exists where there is a large group of people who cannot receive satisfactory signals directly, located within a few miles of a site where satisfactory reception is possible. The most obvious case is a town shadowed by a mountain, see Fig. 1. The system operator installs high-gain antennas and sensitive receiving equipment on top of the mountain where the signals are relatively strong, and distributes them, via coaxial cable, to the homes in the town. Since these signals must be delivered to the customers on the standard television channels between 54 and 216 mc, present practice is to select channels most suitable for the system, and convert the frequencies of the received signals where necessary to fit this pattern. Most of the systems designed by Jerrold Electronics Corporation have used channels *2*, *4*, and *5* (or *6*) because of the lower cable loss on these lower frequencies. A 7-channel system (with nonadjacent channels) is possible using channels *2*, *4*, *6*, *7*, *9*, *11*, and *13*. These two cases will be considered in what follows. Although adjacent channel operation is possible, it has not been used widely because of the difficulties of preventing interference between channels, and it will not be considered.

One of the major problems of community system design, the choice of suitable amplifiers for relaying signals along the main trunk line, will be investigated. Three important possibilities are considered:

1. Separating channels frequency-wise at each repeater point and amplifying each with a separate single-channel cascade amplifier.
2. Separating channels into two groups and amplifying those between *2* and *6* with one broad-band cascade amplifier, and those between *7* and *13* with another.
3. Using a single distributed amplifier for all channels.

A number of the factors affecting this choice are developed, basing the calculations on reasonable but somewhat simplified assumptions. As is often the case with investigations of this type, this one is a little late. Several years of experience have established the single-channel amplifier as the best choice in a large majority of the existing systems. However, a theoretical investigation will serve to show some of the reasons for this choice, and will indicate conditions under which it might not be valid.

FACTORS LIMITING THE ALLOWABLE SPACING BETWEEN AMPLIFIERS

MAXIMUM SPACING between the line amplifiers is desirable because it minimizes the number of points that must be made accessible for maintenance, and the number of power-line connections. Maximum spacing is obtained by reducing cable loss to a minimum, and utilizing the maximum possible amplifier gain.

1. *Cable Loss.* Cable loss is an inverse function of cost, more expensive cables with more copper giving the lowest loss. In practice the cable used has been selected to give the best compromise between cable cost, equipment cost (which decreases as better cables are used), and maintenance. In a majority of installations, *RG11/U* cable is used for the trunk line. Over difficult terrain where accessibility is a major problem more expensive cables such as *RG35/U* have been used.

In the attempt to increase the spacing between amplifiers, amplifier gain cannot be increased indefinitely. A limit

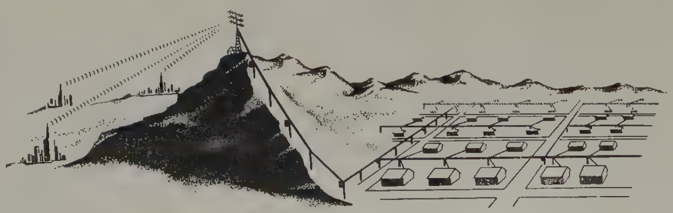

Fig. 1. A typical community television system

Full text of paper **54-101**, "Line Amplifiers for Community Television Systems," recommended by the AIEE Committee on Wire Communications Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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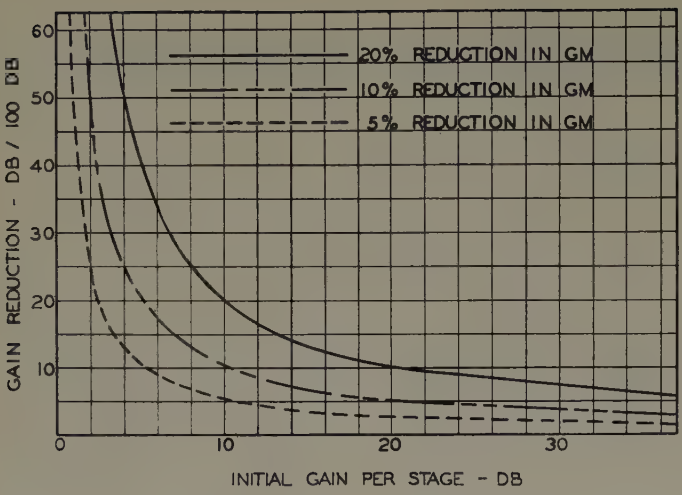


Fig. 2. Gain reduction caused by reduced mutual conductance

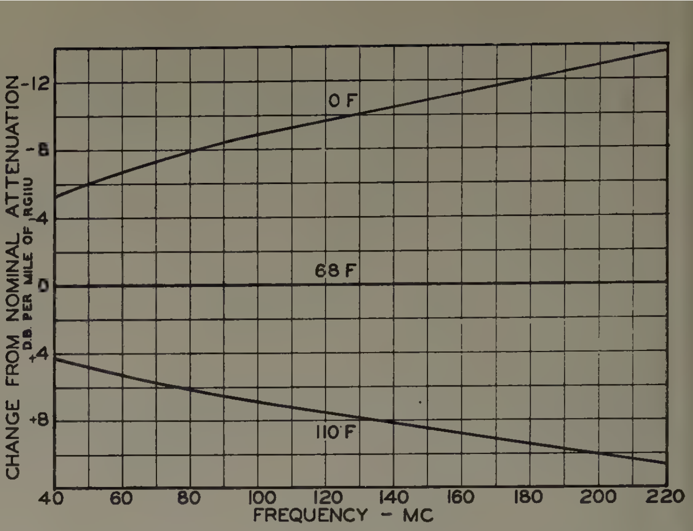


Fig. 5. Calculated change in attenuation with temperature per mile of RG11/U

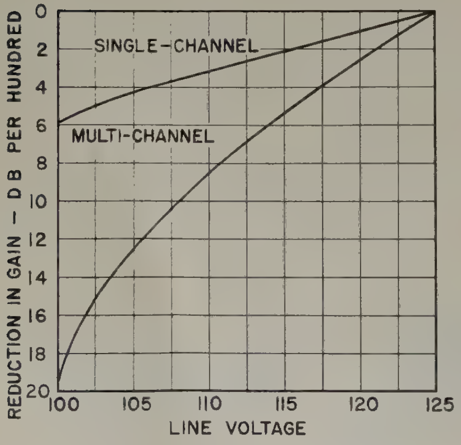
is set by the necessity that the signal level at the input to each succeeding amplifier shall override safely the noise of that amplifier. Maximum spacing is obtained by making the amplifier output level as high as circumstances permit, and obtaining the best possible noise figure in the input stage.

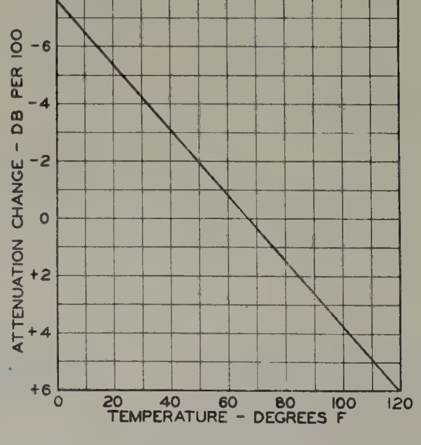
2. *Output Voltage.* In a single-channel amplifier handling a picture carrier and its associated sound carrier, the output voltage into the line can be increased up to the point where the video signal cross-modulates the sound. This shows up as 60-cycle amplitude modulation of the sound carrier, and produces annoying buzz in receivers that are mistuned or have inadequate limiters. In broad-band amplifiers handling several channels, the limit on output voltage is set by cross modulation between picture signals. This becomes serious at somewhat lower levels than those giving sound buzz and it results in moving bar patterns (windshield wiper effects) on the received pictures.

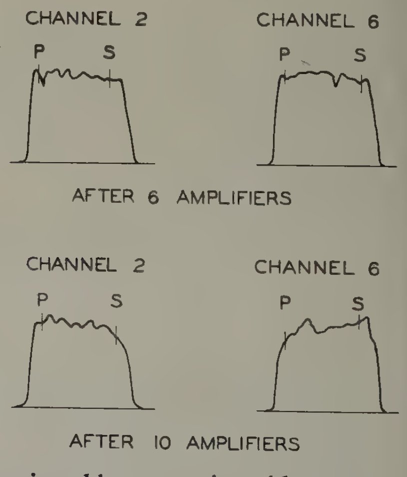
It is present practice in amplifiers for community systems to use small receiving tubes (chiefly *6AK5s* or *6CB6s*) throughout. The output stage is a single tube operated class *A*. With these limitations the output voltage into the cable depends primarily on the bandwidth requirements, and on the efficiency of the output coupling network.

Table I shows the calculated maximum output voltage into a 72-ohm cable obtainable from the commonly used arrangements, assuming about 5 per cent intermodulation and a tube with approximately the characteristics of a *6AK5* or *6CB6* (see Appendix I for method of calculation). The figures are optimistic in that they assume a lossless output circuit of optimum design (this condition is easier to approach in broad-band circuits), and they disregard the reduction in allowable level per channel when a number of channels are present in the output of a broad-band amplifier (this condition does not apply to single-channel amplifiers).

3. *Input Voltage.* The lowest input voltage that may be permitted into a line amplifier depends on the noise figure of the amplifier, and on the lowest permissible signal-to-noise ratio. The minimum input voltage figures in Table II have been calculated from the noise figures shown, based on a noise bandwidth of 5 mc and a ratio of 30 db between noise and white level in the picture signal. By dividing these input voltages into the maximum output







Ffg. 3 (left). Measured gain reduction of two amplifiers. **Fig. 4 (center).** Calculated change in cable attenuation with temperature. **Fig. 7 (right).** Typical system response curves after alignment in place

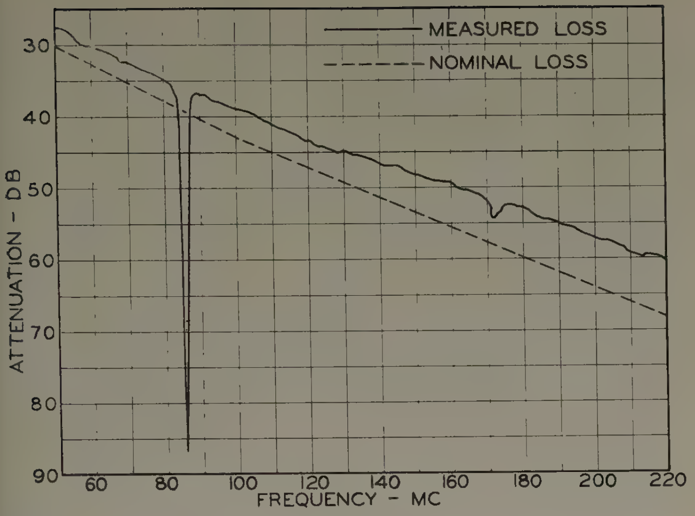


Fig. 6. Loss versus frequency for 2,000 feet of defective RG11/U cable

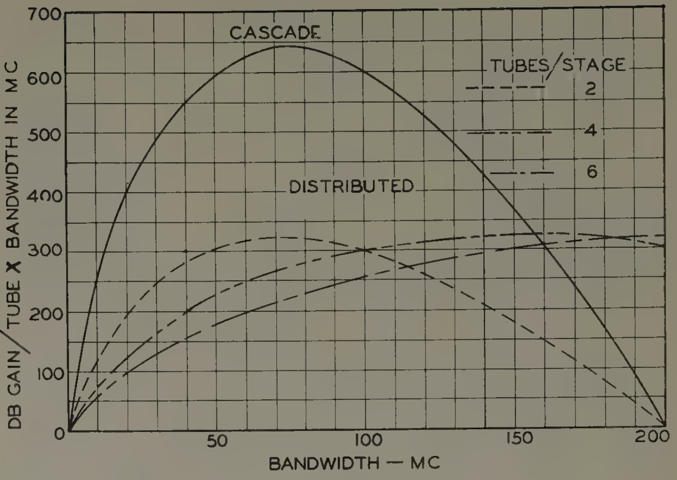


Fig. 8. Decibel gain—bandwidth product versus bandwidth

for each type of amplifier, the maximum possible gain is found. The cable loss between amplifiers must equal the amplifier gain, so the gain figures have been used to calculate maximum amplifier spacing. The use of *RG11/U* cable is assumed.

MINIMIZING GAIN VARIATIONS CAUSED BY TUBES

THE OPERATION OF a repeater system depends on a critical balance between two factors: cable loss and amplifier gain. Variations from normal in either one require means to readjust levels, and sufficient excess gain to allow system operation when cable loss is at its maximum and amplifier gain at its minimum. Even worse, these variations subtract from the allowable loss between amplifiers. Assume, for example, amplifiers with a spread of 60 db between minimum permissible input and maximum output. If signal level, amplifier gain, and cable loss all were constant, these amplifiers could be spaced 60 db apart on the cable. A variation in any one of these three means that the amplifier spacing must be reduced accordingly. A signal variation of 10 db would require reducing the spacing to 50 db of cable, with corresponding gain reduction in the amplifiers, to prevent the signal from varying beyond the limits set by the input and output circuits.

The worst source of fluctuations in a system (except for fading of received signals) is the change in tube gain caused by variations in mutual conductance. This results from supply voltage changes, and from aging; and can be minimized by regulating supplies, and by periodic replacement of failing tubes. Even with the best design and maintenance, it remains a major source of trouble.

A striking fact, and one of great importance in system design, is that tube variations cause less trouble in high-gain stages than in low-gain stages. This results from the fact that a given per-cent change in mutual conductance changes the gain of a stage by the same number of decibels, regardless of the stage gain. In Fig. 2, this effect is demonstrated by plotting amplifier gain reduction, measured in decibels per hundred decibels of initial gain, against the gain per stage. Note that amplifiers with gains of 20 db per stage or more are quite insensitive to variations in mutual conductance, whereas those with gains below 10 db are subject to much greater trouble from this source.

Fig. 3 shows an experimental check on this. The gain of each of two amplifiers was measured, and the line voltage was varied over the range from 125 down to 100 volts, using unregulated power supplies. The broadband amplifier (which had a gain of about 5 db per stage) suffered a reduction of over 17 db per 100 db of initial gain; while the single-channel amplifier, with a gain of about 15 db per stage, had its gain reduced less than 5 db per 100 for the same reduction in line voltage. The amplifier with the higher stage gain would be similarly insensitive to any other factors tending to change the

Table I. Calculated Maximum Output Voltage of Band-Pass Amplifiers, Assuming Tube With Output Capacity of 5 $\mu\mu$f, Output Current of 4.5 Maximum Rms, Optimum Output Transformer, and a 72-Ohm Line

Amplifier	Channels	Bandwidth in Mc	Output Voltage	Relative Level Db
Single-channel cascade	any one	6	3.8	0
Low broad cascade	2 to 6	34	1.6	−7.6
High broad cascade	7 to 13	42	1.4	−8.5
Distributed: 6 tubes per stage	2 to 13	162	2.2	−4.9

Table II. Minimum Input Voltage, Maximum Gain and Spacing, Assuming 30-Db Ratio of Picture White to Noise, and the Use of RGII/U Cable

Amplifier	Channel Nos.	Assumed Noise Fig. in Db	Min. Input in Uv	Max. Output in V	Max. Gain in Db	Max. Spacing in Feet
Single channel	6	6	500	3.8	77.5	3,950
Single channel	13	10	800	3.8	73.5	2,300
Cascade broad-band	2– 6	8	600	1.6	69	3,500
Cascade broad-band	7–13	10	800	1.4	65	2,030
Distributed: 6 tubes per stage	2– 6	6	500	2.2	73	3,700
Distributed: 6 tubes per stage	2–13	10	800	2.2	69	2,160

Table III. Calculated Gain Per Stage and Gain Variability

Amplifier	Gain Per Stage in Db	Gain Reduction for 10 Per Cent Reduction in G_m in Db Per 100
Single channel	30.4	3.3
Cascade broad-band		
Channels *2* to *6*	15.4	6.5
Channels *7* to *13*	13.6	7.4
Distributed amp.—6 tubes per stage		
Channels *2* to *13*	11.4	8.8

individual tube characteristics, such as aging and tube replacement.

The amplifier types being considered here can be compared, as regards their susceptibility to tube changes, by calculating the stage gains to be expected. The results of these calculations are shown in Table III. They assume a gain–bandwidth product of 200 mc for the cascade amplifiers, and of 100 mc multiplied by the number of tubes per stage in the distributed amplifier (see Appendix II for method of calculation).

CONTROL OF CUMULATIVE EFFECTS ON LONG SYSTEMS

1. *Level Variations.* It is an axiom of repeater system design that amplifier performance requirements become increasingly difficult to meet as the length of the system is increased. One of the hardest requirements to meet is that of gain constancy. It is possible, by careful design and maintenance, with the use of regulated supplies, to hold the gain of single-channel amplifiers within a tolerance of perhaps 3 db per 100 db of gain. This means the level at the end of a 500-db system (about 5 miles of *RG11/U*) would vary over a 30-db range due to this cause alone. A further source of variation which can give trouble on long systems is the change of cable attenuation with temperature. The chief cause of this change is simply the change in the conductivity of the copper conductors.

The calculated relation between cable attenuation change and temperature is shown in Fig. 4 and is based on the change of copper conductivity. (See Appendix III.) This curve indicates that normal day-night temperature changes of the order of 20 F are sufficient to account for attenuation changes of 2 db per hundred, which is enough to cause trouble on a long system.

The most effective tool for combating these gain and loss variations is the use of automatic gain control (agc). This operates to hold the output level of the controlled amplifier practically constant for wide variations in input. By using agc at frequent intervals along the system (present practice in Jerrold engineered systems is to control every third amplifier) gain variations are cancelled out before they can accumulate to give trouble. As long as the amplifiers between controlled points are spaced conservatively so they can tolerate their own gain variations and those due to intervening cable, such a system can be extended indefinitely without trouble due to gain variations.

While agc is relatively easy to apply to a single-channel amplifier, it is difficult to find a satisfactory way of controlling a multichannel unit. The relative levels of the various channels change, so controls based on any one channel are apt to allow noise or overload on other channels. Controls which respond to total voltage due to all channels are apt to be taken over by a strong channel, driving the others into the snow.

Perhaps the most workable solution is to break the system up into separate channels at each point where agc is used, but in cases where this is practical, it is generally more satisfactory to use single-channel amplifiers throughout the system.

2. *Frequency Response Variations.* In multichannel amplifiers of the type used for community television, the interstage networks are tuned broadly to cover wide bands. For this reason, there is little difficulty in keeping the response over any one channel sufficiently flat to prevent frequency discrimination in the picture. The problem with multichannel amplifiers is to keep the wide-band response flat enough to prevent variations in the relative levels of the various channels. If this is not done, troubles due to gain variation are exaggerated, and agc is made impossible. Since cable attenuation varies with frequency, it is necessary to correct the amplifier response for this, so as to keep the total response uniform. This is commonly done with cascade amplifiers by aligning them with the correctly tilted response; and with distributed amplifiers by using a correction network which inserts additional loss at the lower frequencies as required to eliminate the tilt. Both schemes depend on agreement between the cable tilt in one direction and amplifier (or network) tilt in the other.

Any variation in cable attenuation slope will upset this relation. Unfortunately, the attenuation curve of various samples of cable varies considerably; and the attenuation curve of any one piece of cable is affected by temperature. Fig. 5 shows the variation from nominal attenuation over the frequency range of interest for temperature extremes to be expected. This is based on the curve shown in Fig. 4. Since the effect of temperature depends on the initial loss, it is greater at high frequencies where the initial loss is high than at low frequencies where it is lower. Thus wide temperature changes introduce a tilt in the frequency response which is hard to take into account in system design.

With single-channel amplifiers, the level variations between channels caused by cable characteristics are corrected by the automatic gain controls, and a much less stringent requirement—that the response be maintained flat on each individual channel—controls the design of the system. Cable response usually does not vary enough over any one channel to give trouble; however, defects in cable manufacture occasionally cause severe irregularities.

Fig. 6 shows a particularly horrible example. This is the frequency response of a reel of cable that was rejected as unsuitable for community work for a reason that is apparent from inspection of the curve. An unfortunate periodic effect in the manufacture of this particular piece of cable resulted in a response which is some 50 db below normal in the middle of channel *6*. Happily, this kind of thing does not happen often, but it is enough of a hazard to make it highly desirable to check the frequency response of each piece of cable that is to be used in a community system before it is installed.

Generally, it has been found possible to hold the frequency response curves of individual channel amplifiers sufficiently flat in production to prevent cumulative response troubles. In cases where extremely long runs are necessary (over 10 miles is "extremely long" in the present state of the art) or where superlative performance is desired on shorter systems, it has been found to be quite practical to align each amplifier in place in the system, using a sweep-frequency generator at the antenna site, and thus cancel out any irregularities and obtain relatively flat curves throughout the system.

Typical response curves obtained on a system aligned in this fashion are shown in Fig. 7. It may be observed that there is almost no cumulative deterioration of the system response as additional repeaters are added.

MINIMIZING THE NUMBER OF TUBES IN A SYSTEM

If the attempt is made to design a system for minimum cost, minimizing the number of tubes (of a given type) would appear to be a reasonable approach. The theory involved in this approach is quite simple, and the results clarify important factors affecting the choice of amplifiers.

Requiring maximum channels with minimum tubes of the individual amplifier stage has the effect of creating a figure of merit for the stage which is the product of the stage gain, in decibels, by its bandwidth in megacycles. This may be called the "decibel gain–bandwidth product" to distinguish it from the more familiar voltage gain–bandwidth product. For a given tube type and coupling network (and certain simplifying assumptions) the latter product is a constant. Since decibel gain is related to the logarithm of voltage gain, this means that the decibel gain–bandwidth product is a variable, depending on bandwidth.

This product plotted against bandwidth for single-tube cascade amplifier stages is shown in Fig. 8, assuming a voltage gain–bandwidth product of 200 mc, and for distributed amplifiers with various numbers of tubes per stage, assuming a voltage gain–bandwidth product of 100 mc multiplied by the number of tubes per stage. The product is divided by the number of tubes in a stage in each case to permit direct comparison. Each curve reaches its maximum at the bandwidth where the gain per stage has the optimum value of 8.7 db (1 napier).

With these assumptions it is apparent that the cascade amplifier is more effective for bandwidths less than about 160 mc, the distributed circuit being more effective at greater bandwidths, and providing the only possibility of gain for bandwidths over 200 mc.

Table IV. Tubes Required Per Mile of RG11/U

	Tubes Per Mile	Tubes Per Channel-Mile
3-Channel System Using Channels 2-4-6		
Cascade 54- to 88-mc amplifier	6.9	2.3
3 single-channel amplifiers	9.3	3.1
Distributed 54- to 88-mc amplifier (2 tubes per stage)	13.7	4.6
7-Channel System Using 2-4-6-7-9-11-13		
Cascade 54- to 88-mc amplifier plus 174- to 216-mc amplifier	19.8	2.8
7 single-channel amplifiers	31.3	4.3
Distributed amplifiers (54- to 216-mc—4 tubes per stage)	54.0	8.0

Table V. Summary of Performance Characteristics

Performance Characteristic	Single-Channel Amplifier	Cascade Broad-Band	Distributed Broad-Band
Output voltage	1	3	2
Input voltage	1	2	1
Spacing along cable	1	3	2
Gain variation	1	2	3
Use of agc	1	2	2
Control of frequency Response	1	2	3
Economy of tubes	2	1	3

Note: Numerals indicate order of preference in regard to each characteristic.

Conclusions drawn from these curves cannot be applied to the community television problem without reservations. Obviously added bandwidth in an amplifier is desirable only when it adds a useful channel. An amplifier would require a bandwidth of 34 mc to pass channels *2*, *4*, and *6;* or 42 mc to pass *7*, *9*, *11*, and *13*. Adding bandwidth in either case to reach 73 mc (optimum according to the curve) would serve only to decrease the gain per stage for the desired channels, with no compensating advantage.

A more realistic approach to the problem of system economy involves finding the number of tubes required per mile of cable for each amplifier type and channel arrangement. Table IV shows the results of these calculations, assuming amplifiers with the gain characteristics shown in Fig. 8. The amplifier gain has been assumed just great enough in each case to overcome cable loss at the highest frequency to be amplified.

The cascade broad-band amplifiers show up well on this basis because their bandwidths fall near the optimum value, and each band is well filled with useful channels. The distributed amplifier suffers from a lower voltage gain–bandwidth product (per tube) and from the fact (in the case of the 7-channel system) that it amplifies a wide band between 88 mc and 174 mc where there are no channels.

Dividing the figures on this table for number of tubes per mile by the number of channels in each case gives an informative result, the number of tubes per channel-mile. This figure allows a comparison between systems having different numbers of channels. It will be noted that the 7-channel system shows greater tube requirements on this basis, reflecting the inefficiency of distributing signals on the higher frequencies where cable loss is increased.

CONCLUSIONS

The various factors discussed in this article are summarized in Table V as they affect the choice between the three basic types of amplifier suitable for line amplifiers in community television systems. The overwhelming evidence favors the single-channel amplifier. Using the same tube types, and making other reasonable assumptions, it has been shown that this type is capable of greater output voltage, and requires no greater input voltage than other types; thus it allows greater spacing between amplifiers with a given cable. Since it has higher stage gain, it is less susceptible to gain variations due to tubes. Automatic gain control may be used much more readily with single-channel amplifiers, and they allow simple correction of frequency response variations affecting relative levels between channels, as well as those affecting the individual channel. In regard to one factor, tube economy, the cascade broad-band amplifier is superior to the single-channel type. It should be noted that all of the other factors are of increasingly greater importance as the system is extended, so that on small systems where cable runs are short and there are few repeaters, the increased economy of the cascade broad-band over the other types may make it the better choice. The same reasoning justifies the use of cascade broad-band units for distributing the signal at points where taps are taken off the trunk line.

Appendix I. Calculation of Output Voltage of Band-Pass Amplifiers

The following assumptions are made:

C_p (output capacity of tube) = 5 $\mu\mu$f
R_L (load resistance) = 72 ohms
E_L is rms load voltage
I_p (maximum rms plate current) = 4.5 ma. (This figure was obtained graphically from the characteristic curves for *6AK5* and *6CB6* tubes, and represents the plate current variation at 5-per-cent intermodulation.)
E_p is rms plate voltage

The output transformer is assumed to consist of a band-pass filter with characteristic resistance R_o, and C_p as a full shunt arm, followed by a lossless transformer matching R_o to R_L. BW (the bandwidth for flat response) is assumed equal to $0.9f_c$ (f_c is the cutoff frequency of the filter).

For a single-tube output stage:

$$R_o=\frac{1}{\pi\ f_c\ C_p}=\frac{0.9}{\pi\ BW\ C_p}$$

$$E_p=I_pR_o=\frac{0.9\ I_p}{\pi\ BW\ C_p}$$

$$E_L=E_p\sqrt{\frac{R_L}{R_o}}=I_pR_o\sqrt{\frac{R_L}{R_o}}=I_p\sqrt{R_LR_o}$$

$$=4.5\times10^{-3}\sqrt{\frac{72\times0.9}{\pi BW\times5\times10^{-12}}}=\frac{9.2}{\sqrt{BW_{mc}}}\text{ volts rms}$$

For the output stage of a distributed amplifier:

The output current of each tube splits two ways, one-half flowing in the output load circuit. For the same bandwidth the band-pass filter will have the same constants as the foregoing. With n tubes the total plate current will be $n/2\times I_p$. And thus the load voltage will be

$$\frac{n}{2}\times\frac{9.2}{\sqrt{BW_{mc}}}=\frac{4.6\ n}{\sqrt{BW_{mc}}}$$

Appendix II. Calculation of Voltage Gain–Bandwidth Product

Assume:
Total interstage capacity C_t = 14 $\mu\mu$f
Mutual conductance G_m = 5,000 micromhos
A 4-terminal interstage in the form of a band-pass filter with characteristic resistance R_o and $C_t/2$ as full shunt arm. Bandwidth of flat response (BW) equal to 0.9 of the filter cutoff frequency (f_c).

For cascade stage:

$$\text{Gain per stage}=G_mR_o=\frac{G_m}{\pi f_c\frac{C_t}{2}}=\frac{0.9G_m}{\pi BW\frac{C_t}{2}}$$

$$\text{Gain}\times\text{bandwidth}=\frac{0.9\ G_m}{\pi\frac{C_t}{2}}=\frac{0.9\times5{,}000\times10^{-6}}{\pi\times7\times10^{-12}}\approx200\text{ mc}$$

For a stage in a distributed amplifier:

The plate current of each tube splits two ways, so one-half flows into a load resistance of the filter. With n tubes in a stage, the gain is $n/2\times$cascade stage gain.

$$\text{Thus gain}\times\text{bandwidth}=\frac{n}{2}\times200\text{ mc}=100n\times\text{mc}$$

Appendix III. Calculation of Change in Cable Attenuation With Temperature

Neglecting dielectric losses, the cable attenuation, A, is proportional to the total r-f resistance of the conductors (R_{ac}). (See, for example, FTR "Reference Data for Radio Engineers," 3d edition, p. 319.)

Since the r-f resistance of a cylindrical or tubular conductor is proportional to the square-root of the resistivity (*loc. cit.*, p. 86) for fixed geometry:

$A\propto R_{ac}$ R_{ac} and $\propto\sqrt{R_{dc}}$ so $A\propto\sqrt{R_{dc}}$

but:

$R_{dc}=R_{20}[1+0.00393(T-20)]$(*loc. cit.* p. 41)

where

R_{20} = d-c resistance at 20 C
T = temperature C

$$\frac{A}{A_{20}}=\sqrt{\frac{R_{dc}}{R_{20}}}=\sqrt{[1+0.00393(T-20)]}$$

and attenuation change in decibels per 100 db of initial attenuation =

$$100\ [A/A_{20}-1]=100[\sqrt{1+0.00393(T-20)}-1]$$

Radomes of Sandwich Material

Directional radomes utilizing a new wall construction (type *B*) have been developed by McMillan Laboratory. Type *B* construction permits the transmission of microwaves at any angle of incidence without alteration of polarization, and with or without change of direction, whichever is desired. With this sandwich, radomes have been designed with negligible cross-talk and extremely low reflection. This wall material allows extreme streamlining configuration such as ogives and cones. Streamlining can be accomplished without any effect on electrical performance. Type *B* construction is a sandwich of thick low-dielectric skins with a thin high-dielectric core and is rugged and durable.

Principles of Operations Research

J. B. LATHROP

In recent years, scientific research has been moving out of the laboratory into new fields to deal with management problems by attempting to reach an understanding of the operation involved. In this respect, one of its essential elements is the development of an operations research model from which phenomena can be deduced to check against the observed facts.

DURING the last few years, scientists and research people have been leaving their laboratories or research projects with increasing frequency to deal with problems in new areas. From the development of new products and processes, they may move on to questions of how these new developments affect sales or costs, to the scheduling of their production, to distribution, to the evaluation of promotional or advertising efforts. In their work with the military services, to the development of new weapons and equipment, scientists have added the study of the tactics and strategy surrounding the use of weapons. The term "operations research" has been applied to much of this activity. Operations research has been described as the application of the scientific method to problems of executive decision where it has not been employed previously but where it can be proved useful. This broadening of the range of application of the methods of research is so great that some say it requires the appellation of a new branch of science.

Meanwhile, many of those engaged in established branches of research and engineering wonder where operations research fits into their activities. Systems engineering, industrial engineering, market research, etc., all provide quantitative information on which to base management action. Underlying these disciplines are techniques developed from research in mathematics, statistics, and other fields. Operations research is certainly closely related to these other activities, and often is concerned with much of the same types of problems, but with some important differences in viewpoint and method.

THE OPERATIONS RESEARCH MODEL

PERHAPS these relationships can be illustrated best by pointing out some of the general principles and characteristics which seem to underlie typical operations research work.

As in science, the primary objective of operations research is to understand, not to act. When an operation is understood, when the mechanism or systematic organization underlying the observed facts are discovered, the action to improve the process is often fairly evident. It is in the obtaining of this initial understanding that the scientific method comes in.

The scientific method, as referred to in operations research, is a combination of quantitative hypothesis, observation, and controlled experiment which is typical of much of the research in the physical sciences and certainly not unknown in statistical analysis. Its essential elements include the development of a simplified quantitative model of the operation studied and the testing and refinement of the model by quantitative observation and controlled experiment. Rather than reasoning from the facts to the mechanism, as in some forms of statistical analysis, the operations research scientist more often sets up assumed models in order to deduce phenomena to check against the observed facts. The details of the model usually are expressed mathematically and the consequences of alternative courses of action, inherent in the model, derived by mathematical procedures.

Surprisingly simple models derived in this manner, expressing the effects of a few important factors, often can provide an understanding of very complex operations. Newton was able to explain the immensely complicated paths of the planets and their satellites, as well as the apparently unrelated phenomena of objects falling on the earth, in terms of the simple unifying concept of gravity. Mendel, working only with a few unimportant characteristics of the reproductive process, was able to evolve the statistical laws governing inheritance.

Consider a simple example of an operations research model, the representation of an operation in terms of the factors of primary importance to the problem under study. A company wished to set time standards for cost accounting and labor control on the operations of a battery of taping machines. These machines wind a variety of protective tapes on cables produced by the company. The machines had been purchased at different times and were felt to be rather varied in operating characteristics, although the principle of operation was the same in all. The cable is pulled through the center of a rotating disk, the "taping head," which carries a roll of tape which is unwound through a set of rollers and presented to the cable at an angle. Several kinds of metallic, paper, cloth, and rubberized tapes were used, and the diameter of the cable treated varied widely.

Time study methods had failed to yield adequate standards because of the complexity and variability of the operator's tasks and the uncertain effects of changes in materials. Statistical methods applied to job records of the time and character of jobs failed to explain the variations in time required, and there appeared to be sub-

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Full text of a special article recommended for publication by the AIEE Committee on Research.

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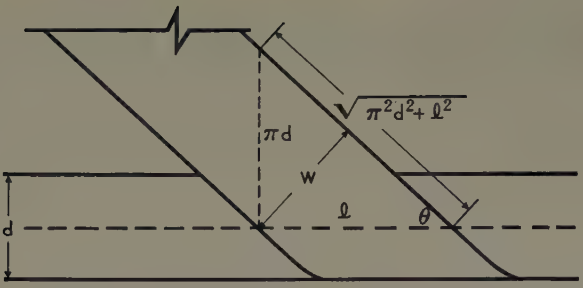

Fig. 1. Operations research model set up for the determination of standards in the operation of taping machines

stantial differences in efficiency among machines and operators.

Discussions with operators and foremen indicated that setup and starting time and complexity were largely the same for all jobs, but the workers set the machine speeds from experience and "feel" of what the tapes used would stand without undue breakage. Investigation indicated that the tension in the tape was proportional to its speed and the tensile strength was proportional to its width, so a model was devised to include these relationships. See Fig. 1.

The simplest unit of production is the amount produced by the machine in one revolution of the taping head, the unit recorded on the work sheets as the "lay" of the tape. If the taping head turns at n revolutions per minute, the time required for a job is

$$T = t_0 + \frac{L}{nl}$$

where t_0 is setup time, l is the "lay," and L is the length of cable in the job.

From the geometrical relationships the velocity of the tape was

$$n\sqrt{\pi^2 d^2 + l^2}$$

where d was the cable diameter; and the maximum tension the tape would stand was

$$Kn\sqrt{\pi^2 d^2 + l^2}$$

where K depends on the strength of tape used. The maximum speed of the machine was

$$n = \frac{Q_i w}{\sqrt{\pi^2 d^2 + l^2}}$$

the tensile strength of tape material.

The cable diameter and lay were set independently and an appropriate tape width chosen. The required width, from Fig. 1, is

$$w = l\frac{\pi d}{\pi^2 d^2 + l^2}$$

and thus the maximum speed for the machine was

$$n = \frac{Q_i l \pi d}{\pi^2 d^2 + l^2}$$

The time required to cover a cable of diameter d and length L, with a tape of material type i, at a lay l, would be expected to be, therefore:

$$T = t_0 + \frac{L}{Q_i l} \cdot \frac{\pi^2 d^2 + l^2}{l \pi d}$$

Application of this model to routine job production records, with appropriate allowances for the types of tape material used, showed the operation was surprisingly uniform and the behavior of machines and operators surprisingly similar. Apparent differences were due to unnoticed effects of differences in jobs handled. A direct basis was available for setting uniform and reasonable time standards.

The operations research model is usually in mathematical form, but not necessarily so. Components of an operation may be represented by punched cards and masses of these manipulated on automatic equipment to demonstrate and evaluate the effects of alternative courses of action. The model may be physical, as in the cases of electronic or hydraulic analogies to distribution networks.

Fundamental to the concept of the model of an operation is the notion of a measure of effectiveness, or explicit measure of the extent to which an operation is attaining its goal. It may be quite different from that customarily employed. As an example, during the war the Navy provided crews to man antiaircraft machine-gun defenses for merchant vessels. It was noted that the proportion of attacking enemy aircraft shot down by such batteries was very small compared with antiaircraft experience of naval warships. It was suggested, therefore, that the naval gun crews could find better employment elsewhere and should be withdrawn from merchant vessel assignment. Closer study indicated, however, that in the case of merchant vessels defended by machine-gun batteries, the ships hit per attacking aircraft were much lower than for undefended vessels. The correct measure of effectiveness to employ in this decision was ships hit per attacking aircraft, rather than aircraft shot down per attack.

A recent operations research study concerned with evaluating the effectiveness of a chain of retail outlets for a large manufacturing company found that different officers of the company were applying, perhaps unconsciously, widely differing measures of effectiveness in reaching conclusions as to the success of the retail chain. The president felt that the chain should be operated in such a manner as to maximize profits to the company; the treasurer wanted to see them adjusted so as to maximize return on invested capital; the sales manager was interested in gross margin, or sales less sales expense. It was discovered that these varying measures of effectiveness were mutually incompatible, and that the store chain could not be operated to maximize them all at once. It was necessary to develop a new and different measure which represented in proper proportions the interests of the various officers of the company, and to which they could all agree.

SOME TECHNIQUES INVOLVED

A GREAT DEAL has been said from time to time concerning the techniques used in operations research. Attempts have been made to associate operations research with specific techniques, frequently with statistical methods, often with particular branches of mathematics, sometimes with rather specialized forms of engineering. However, the identification of operations research with any specific technique must be recognized for what it is—an oversimplification and a misapprehension. Mathematical and experimental techniques help the research attack, but no amount of technique can replace it. The research scientist will use any techniques at his disposal which fit the problem. Some of the techniques which have been found particularly useful in operations research problems include calculus, differential equations, statistical mechanics drawn from physics, linear programming, and the theory of experimental design drawn from statistics. Communications theory, servomechanisms theory, symbolic logic, and queuing theory all have provided the bases for solving operations research problems.

Because the technique most useful for a particular problem cannot be selected in advance, and many are usually tried before some are chosen, operations research tends to work best as a team effort. Research scientists, most often from the physical sciences, mathematicians, and statisticians, as well as engineers, will be members.

Actual experience with operations research shows that it complements, rather than competes with, other services aiding management, such as accounting, industrial engineering, etc. Operations research has proceeded most rapidly and economically in those companies in which other management service activities already have been developed to a high level of efficiency. In such situations, the role of operations research is frequently that of integrating information, of using expert opinion and factual data provided by these other services in an organized, comprehensive, and systematic analysis directed toward management problems.

SUMMARY

To summarize, operations research is a branch of scientific research, which is concerned more with reaching an understanding of an operation than with the relations among the numbers describing the operation. It usually is carried on by teams of people, drawn from engineering, mathematics, and the physical sciences. It certainly is not new, except possibly in the growth of the idea of bringing together the approaches and techniques of many disciplines, to bear on management problems where they had not been used together before. It has been found useful in such diverse management problems as choosing equipment design, locating plants, scheduling production, planning warehouse stocks, and establishing bonus systems. It points the way for industrial research groups, with their reservoir of trained people, to make real and substantial new contributions to problems of top management.

Largest Stator Ever Shipped From U. S. to South America

The largest stator ever shipped from the United States to South America, as ordered by Stone and Webster Engineering Corporation for the steam-electric power station an affiliate is building for the São Paulo Light and Power Company, Ltd., São Paulo, Brazil, is shown being loaded aboard the *S.S. Mormaclark* bound for Rio de Janiero.

The 130-ton stator, part of an electric generating unit with 100,000-kw capacity built by the General Electric Company, Schenectady, N. Y., is the first of two such stators destined for the $32,000,000 plant which, when completed, will be the largest steam power station in Brazil with a total power capability of 200,000 kw.

As São Paulo is situated on a plateau 2,500 feet above sea level, it was found necessary to ship the huge generating unit via Rio de Janiero even though the rail trip from there to São Paulo is about 250 miles longer than via the port of Santos. Because the Santos–São Paulo run includes stiff grades, 13 tunnels, and 16 bridges, it was found that the stator would not clear many of these obstructions.

The stator, which is 13 feet high by $12^1/_2$ feet wide and is the second largest ever exported from this country (the only one larger is in Paris, France), will be shipped from Rio de Janiero only after engineers carefully have surveyed the route, built a template duplicating the stator's over-all size, and had it piloted slowly over the railroad that will transport the real unit up to São Paulo. Power from the new São Paulo station will supply that city.

Precise Measurement of Repeater Transmission

THADDEUS SLONCZEWSKI
MEMBER AIEE

The transmission of a repeater section consisting of 4 miles of coaxial cable and a repeater including equalizing networks was measured in the laboratory. The measuring circuit was switched between the unknown and a short reference strap at a rapid rate. This reduced the effects of level drifts in the measuring oscillator amplifier and detector to a point where an accuracy of ±0.001 decibel over a range of ±0.05 decibel was obtained. The measurements were automatically recorded in pen and ink over a frequency range of 0.1 to 8.3 megacycles.

LONG TOLL transmission lines passing wide frequency bands must meet severe requirements of equalization of loss with frequency. A new wide-band coaxial system under development will have a large number of repeater sections in tandem. The over-all equalization required is such that systematic variations in the transmission characteristic from 0.2 to 8 megacycles of one section must be known within 1/1,000 of a decibel. On the other hand, a range of only ±0.05 decibel needs to be covered.

The experimental work is carried on in a temperature-controlled laboratory housing the repeater, together with a section of cable wound up on reels. Thus the transmission of a typical section can be measured by connecting its input and output to a transmission-measuring instrument in the laboratory.

To fill the need for measurement of transmission to the required precision the circuit shown on Figure 1 was developed. An oscillator and detector whose impedances are equalized to match the coaxial cable impedance are alternately strapped together or connected through the repeater section. The variation in the detector output voltage is a measure of the insertion loss, or gain, of the unknown.

The difficulty that has to be overcome is that in the time it takes to switch between the unknown and the strap and to observe the voltage variation, both the oscillator level and the detector sensitivity may drift by more than 0.001 decibel.

The solution adopted is to switch at the rate of 60 cycles. It is found that within 1/60 of a second the total drift in the circuit is less than 0.0002 decibel.

In addition to being fast-acting, the switch must be a good transmission element. The mercury switch, see Figure 2, which is a modification of a standard switch,[1] meets both requirements. The switch is enclosed in a cylindrical shield separating it from the driving winding. The leads are brought out to coaxial jacks in cylindrical cavities. The diameters of the cavities are proportioned to provide a 75-ohm impedance matching that of the coaxial cable. Note the bulging out of the cavity at the point where the mercury pool increases the diameter of the inner conductor. The complete relay includes three jacks into which the unknown and the strap may be plugged.

The net effect of properly distributing the capacitance and inductance of the relay is that it presents a negligible impedance irregularity at all frequencies up to 80 megacycles. It introduces into a circuit a transmission loss caused by the resistance in the leads, which are made of permalloy. The loss rises from about 0.01 decibel at 1 megacycle to 0.02 decibel at 10 megacycles. However, the losses for the two switch positions are matched to better than 0.0002 decibel up to 8 megacycles.

When the switch is open, its gap is bridged by a direct capacitance of about 0.3 micromicrofarad. The effect of this coupling is reduced to a negligible value by using for a strap 1 foot of coaxial cable. The capacitance of the cable forms the shunt arm of a T network which attenuates the pickup signal that is fed through the capacitance in the open position. As seen on Figure 1,

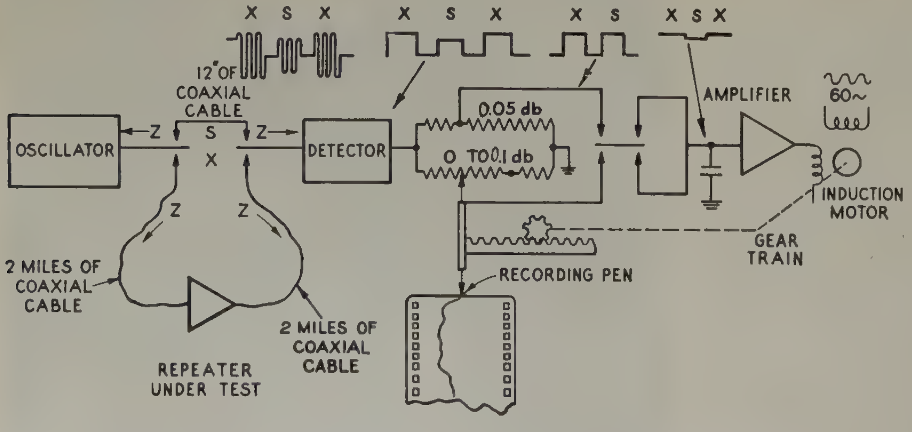

Figure 1. Block diagram of the repeater loop and measuring circuit

Full text of a conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953, and recommended for publication by the AIEE Committee on Instruments and Measurements

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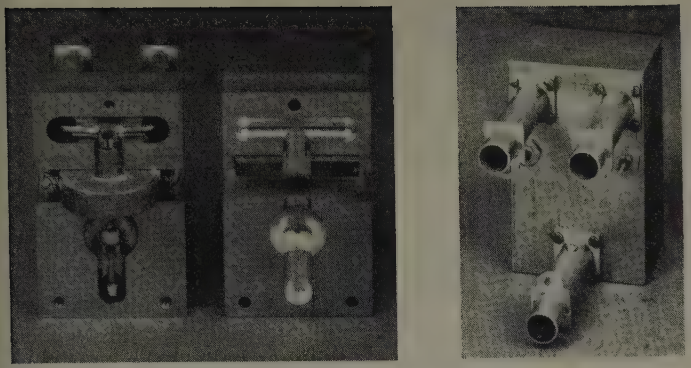

Figure 2. Complete coaxial switch

the detector is followed by either a fixed or a variable attenuator which is alternately switched in and out as the unknown or the strap is switched. The rectified signal, which is of the form of a 60-cycle square wave, is nulled by adjusting the variable attenuator. When a null obtains, the repeater loop gain equals the setting of the attenuator.

The timing of the switches is so arranged that while the switching transients are being dissipated, the amplifier that follows the attenuator is disconnected from the circuit and its input voltage is held constant by the charge on a capacitor.

With such an arrangement, none of the circuit constants is critical. Because a square law rectifier is used, an additional two to one advantage is obtained so they would have to vary by 2 per cent to produce an error of 0.001 decibel.

In order to obtain the results rapidly in the form of a pen and ink record, the attenuator, which is of the form of a potential divider, is motor driven, while the motor is energized by the amplifier following the attenuator. Thus the circuit nulls itself automatically. The paper drive and the oscillator are linked by a servomechanism which insures that the frequency scale fits a preprinted linear grid.[2] A sample of the result obtained is shown on Figure 3.

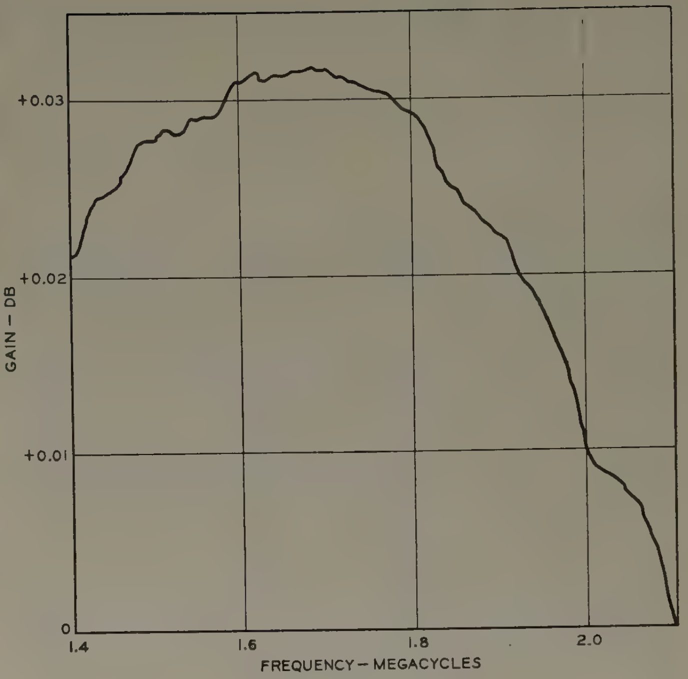

Figure 3. Portion of a record

The accuracy of the instrument was checked by measuring known lengths of coaxial cable whose attenuation for long samples had been measured by other methods. The largest discrepancy was found to be 0.0009 decibel.

While developed primarily for repeater transmission measurement, the circuit may be used for intercomparison of any two 75-ohm networks whose transmissions differ from one another by less than the range of the instrument, ±0.05 decibel, and varies by less than 15 decibels which is the automatic-volume-control range of the detector. Thus manufacturing variations in a network may be detected against a network standard.

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New Betameter Design for Coating Measurement

Originally designed by Isotope Products Ltd., to serve a specific need in the paper industry, the betameter evolved into the betamatic to provide continuous production control. Now a betameter instrument has been developed to measure the mass of adhesives on tape, thickness of carbon black on carbon tissue, or other coating applications.

For coating applications, two measurements of sheet thickness must be made, one of the sheet mass before coating, one after. The difference is the mass of coating applied. Isotope Products' new coating gauge effectively provides differential measurement of coating applications with one instrument. Where the betameter is balanced by an internal set of duplicate source and detector, the coating gauge balances one measuring head against the other. Both detector heads are connected with an amplifier which records the difference in signals and relates the coating measurement to a recorder or control system.

In the betameter the current flowing from the ion chamber detector is balanced against a second circuit in the internal detector. Both circuits are well insulated within the instrument against external interference. But the coating gauge employs two detector heads which can be up to 20 feet apart. The two heads feed into an amplifier at a central point. To provide stable operation free from vibration and electrical interference, Isotope engineers employed a flexible low-noise cable which carries the tiny circuits from detector heads to amplifier without any possible distortion.

A Stray Loss Problem in Transformer Tanks

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IN THE DESIGN of transformers, there are a great many problems regarding fields. Both dielectric and magnetic fields are involved and most of them are extremely difficult to solve mathematically. One problem involving the magnetic field is that of stray losses and heating of tanks. A specific case illustrative of this problem is the core-type transformer with unbalanced windings.

The usual core-type transformer consists of an iron core, built up in cruciform shape, and concentric low- and high-voltage windings, and with the low-voltage winding next to the core. The leakage flux of this arrangement is largely axial when the windings are of equal length and uniformly distributed. However any irregularity in the distribution of the windings will create a radial component in the field of the leakage flux. The radial field will affect the transformer reactance, stray losses, and the mechanical forces on the windings.

The most common cause of unbalanced winding is "tapped-out" sections. It is common to tap out as much as 15 per cent of the high-voltage winding at its center. An extreme case is obtained when a section of the low-voltage winding is "tapped out" which is not opposite the hole in the high-voltage winding. The problem is to determine the resultant magnetic fields at the tank wall and the losses due to them.

The general transformer leakage field was studied first to determine the transformer reactance and considered only the case of balanced windings. Roth and Rogowski also analyzed the more general leakage field of the transformer but their results are in the form of a Fourier series and do not seem practical for general use. The solution of the leakage field is not a simple one but is necessary in order to determine the performance of the transformer. Simple methods which give results of sufficient accuracy are in constant demand by designers. The methods should give a true physical picture so that their limitations are apparent and should not be empirical.

The loss in the tank walls is due to leakage flux entering the tank wall. Since the tank wall is parallel to the coil columns and since the flux will enter the tank at approximately a 90° angle, the radial component of the leakage flux was believed to be the most important factor. The field strength at any point can be found easily if the transformer winding is replaced by an equivalent current sheet. The radial component of the field of the current sheet is

$$B = 0.2\ A \ln a/b$$

where

A = current density in the sheet
a = distance from point to edge of sheet
b = distance from point to opposite edge of sheet

The transformer windings can be broken up into the required number of current sheets and the field calculated separately for each sheet. The shape of the radial field calculated in this manner was confirmed by search coil measurements made on an actual transformer.

The problem of the behavior of magnetic flux within solid materials of high permeability is a most difficult one unless some simplifying assumptions are made. A method developed by Dr. E. Rosenberg was investigated and was found to yield usable results.

This method determines that the flux will penetrate only a small distance into the iron. A formula for the loss in the iron due to the circulating eddy currents is

$$P = 1.19 \times 10^{-4} \sqrt{\rho f N^3 B} \text{ watts per square centimeter}$$

where

ρ = specific resistivity in ohms per cubic centimeter
f = frequency in cycles per second
N = magnetizing ampere-turns per centimeter (crest)
B = flux density in gausses

The loss is therefore not a function of the thickness of the tank wall for the usual magnetizing forces involved.

The magnetizing force, N, can be calculated for any point by equating the sum of the radial fluxes up to any point to the flux in the tank wall plus the flux in the space between the tank wall and high voltage winding. A point-by-point solution must be made to determine the total loss in the tank wall. In general it is only necessary to determine the maximum loss and the resulting temperature of the tank wall at that point.

The tank losses calculated for a 3-phase transformer in an oval-shaped tank was 5.5 kw, the measured tank loss was 5 kw. The eddy current loss that would be required to produce the observed maximum tank hot spot is 3.6 watts per square inch. The calculated maximum loss was 3.8 watts per square inch. A further check was the physical location of the tank hot spot. The calculation of the radial flux determined that the tank hot spot should be 7 inches below the top of the high-voltage coil, and the actual distance was found to be 8 inches.

The use of the "current sheet" to replace the actual transformer windings seems to be a very satisfactory approximation. Once the fields have been determined, it is possible by using Rosenberg's methods to estimate the losses in the tank wall. It should be pointed out that the methods used to determine the fields and the losses are not empirical, but follow physical laws as closely as practicable. It also permits predetermining the effect of unbalanced windings on tank temperatures and losses, which are both important to the designer.

Digest of paper **54-119**, "A Stray Loss Problem in Transformer Tanks," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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A Transducer Using a Short-Circuit Rotor

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AS CONTROL EQUIPMENT becomes more automatic and accuracy requirements increase, more highly specialized position-sensing equipment becomes necessary. In the signal-generator type of position-sensing equipment, angular rotation of the input shaft causes a proportionate voltage to appear as the output of the device. It is usually desirable that the output be of line frequency and phase sensitive, that is, that the voltage increases on either side of a minimum or null voltage position and the phase of the output shift 180° as the rotor passes through the null position. This article describes a signal generator which has two unique characteristics: (1) the output is practically unaffected by linear motions of the rotor, and (2) magnetic side pull on the rotor is negligible even when the rotor is not centered.

As shown in Fig. 1, the pickoff is comprised of a soft iron laminated stator having four salient poles. On each pole is a coil having a simple winding. The two sets of diametrically opposite coils are wound series aiding, one set, marked *E*, acting as the excitation windings, the other, marked *P*, as output windings. A short-circuited turn of nonmagnetic conducting material, such as copper, is placed so that it links the excitation flux. With the rotor in this position the a-c excitation flux generates a large circulating current in the short-circuited turn. If the plane of the short-circuited turn is inclined with respect to the axes of the output windings, a component of the flux generated by the short-circuit currents will link the output coils and an output voltage will result. Since, for small angles, the component of flux linking the pickoff coils is proportional to the angle through which the short-circuited turn rotates, the output is linear with angle. The output is phase sensitive since the direction in which the flux passes through the output windings depends on the side of null from which the short-circuited turn is rotated.

If the short-circuited turn were rotated 90° so that it linked no excitation flux, no circulating current would be generated in it. This is a second null position of the signal generator. If the short-circuited turn is rotated slightly from this position, a component of excitation flux will pass through it and a small circulating current will flow. This short-circuit current constitutes ampere turns about the output coils. The result is that similar gradients, i.e., the derivative of output voltage with respect to angular position, are obtained about any of the four 90° null positions.

From the principle of operation and from geometric considerations it can be seen that moving the short-circuited turn rotor axially or in any radial direction will induce negligible voltages in the output winding when the rotor is at the null angular position. Similarly, geometric relationships are such that the voltage and voltage gradient are relatively independent of small linear motions of the rotor.

In an efficiently designed unit having a 2-inch outside diameter stator and an aluminum rotor, the output gradient was 0.63 volt per degree and the output was linear over a ±10° range. The power consumed was 0.40 watt at 400 cycles and the null voltage was 2.5 millivolts. For ±0.015-inch linear radial and axial shifts of the aluminum rotor, the gradient and null position were practically unaffected.

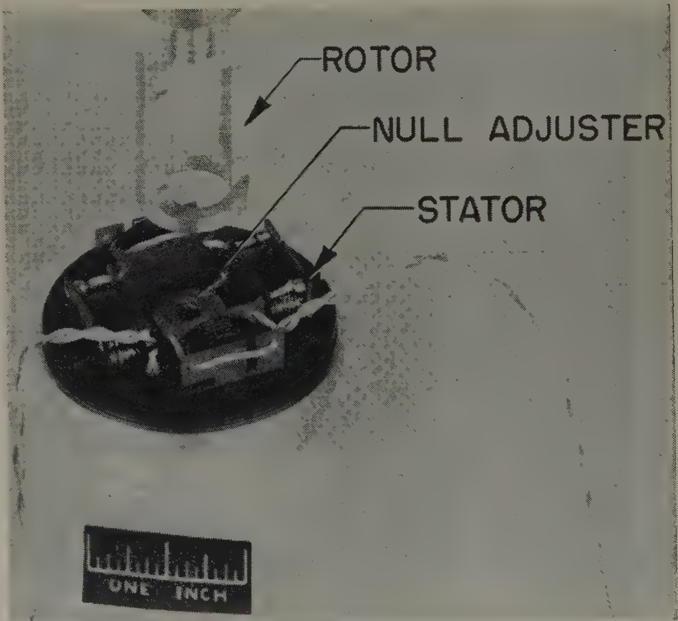

Fig. 1. Signal generator with short-circuited turn rotor. Rotor removed from stator

With the rotor positioned so that it linked the excitation flux at null, the torque gradient on the rotor was about 1 dyne-centimeter per degree and the torque was unstable. About the second null position, the torque was stable, and the gradient was about 10 dyne-centimeters per degree. The effect of temperature was that at −30 C, the output was 10 per cent greater than at 25 C and at +95 C, it was 10 per cent smaller. The null position remained fixed at all temperatures.

By constructing the rotor to suit the application, very compact designs are possible. The units are versatile in application and are particularly suited to the field of instrumentation.

Digest of paper **54-172**, "A Signal Generator Using a Short-Circuit Rotor," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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High-Speed Control by Frequency-Shift Audio Tones

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ASSOCIATE MEMBER AIEE

Industrial applications of audio-tone equipment make numerous unique design requirements. However, the design of this equipment has been facilitated by utilizing experience gained in designing carrier-current equipment to perform these same functions. High reliability has been emphasized to keep total costs to the user at a minimum.

THE rapidly growing use of microwave channels by industry has been accompanied by increased attention to the need for improvements in the designs of audio-tone equipment as employed for control and telemetering over an audio-frequency channel such as is furnished by microwave or carrier-current equipment or by a wire line. In the past there has been some audio-tone equipment designed specifically for these industrial applications but, in general, it has been more common to find that equipment designed for Teletype and telegraph simply has been adapted. This frequently has led to the use of equipment not fully suited to the job and often having serious shortcomings.

The industrial applications to be considered in designing this type of equipment cover a very wide range including telemetering of several types, supervisory control, remote control, load control, ringing, dialing, Teletype, telegraph, transfer-trip, and protective relaying. Except for the last two applications, it is considered practical to multiplex one or more of these types of functions on a single wire line or on a carrier-current voice channel by means of audio-tone equipment. All of the foregoing functions have been multiplexed on a wide-band microwave channel by means of the audio tones. This wide variety of applications dictates a number of unusual features and in working out the design details considerable assistance has been derived from work on carrier-current equipment designed for use by the electrical utilities for these same functions.

GENERAL CHARACTERISTICS

INDUSTRIAL functions characteristically require the utmost in reliability with emphasis in many instances being placed on the great need to guard against false operation of the end device. This consideration has dictated the use of frequency-shift modulation as contrasted to amplitude modulation (keyed carrier). Other characteristics such as the frequency spacing and the selectivity are dictated by the bandwidth or speed of response requirements of the functions to be performed. The theoretical relationship between bandwidth and speed of response in control channels has been discussed.[1] This theory, as borne out by actual timing and bandwidth tests on the audio-tone equipment, has resulted in the frequency arrangement that is provided as shown in Table I. In all cases the arrangement is designed to provide the maximum possible number of channels consistent with certain practical design problems. See Fig. 1 for selectivity curves in medium-, high-, and very-high-speed groups.

A spacing of 120 cycles per second (cps) is available between 420 and 2,580 cps. The frequency shift for this group is ±30 cycles and the filter design is such as to provide a maximum nose-width (bandwidth at 3-db points) consistent with the required selectivity so that the bandwidth characteristic in this range is adequate for high-speed telemetering channels having a maximum modulating frequency of 35 cps. This bandwidth also is adequate for impulse-duration and impulse-rate telemetering, remote control, load control, ringing, dialing, Teletype, telegraph, and for transfer-trip where high-speed operation is not essential.

A higher speed group is provided in the frequency range of 1,620 to 7,380 cps in order to provide for the high-speed functions such as space-code supervisory control and high-speed transfer-trip. Here the bandwidth is adequate for over-all channel operation time of less than 10 milliseconds, which speed is consistent with that found desirable in carrier-current equipment designed for this use and which has found extensive application in recent years.[2] The frequency shift of this group is ±90 cps. As shown in the chart any of the lower speed functions may be performed by the higher speed units. The higher speed units normally would be used for all functions above 2,580 cps, since the top frequency of the low-frequency group is set by practical considerations in the design of the tuned circuits.

The very-high-speed functions of protective relaying are performed by the group having the greatest bandwidth. These, as previously mentioned, are provided primarily in order to multiplex such functions on microwave channels. With FM microwave these functions are generally multiplexed above the voice range for the simple reason that the bandwidth required is substantial and more efficient use of the total microwave bandpass can be made by placing the highest speed functions at the highest

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Full text of paper 54-86, "High-Speed Control by Frequency-Shift Audio Tones," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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tone frequencies. Note, however, that in all instances there is provision for the higher speed functions within the voice band also, primarily for use on microwave systems which have channels that only pass frequencies in the voice range.

In this regard a difficult problem is posed if a situation arises requiring that more than one channel of protective relaying be provided on a single voice range channel of a microwave system. This causes a conflict between the available bandwidth and the required speed of response, so that if two or more such channels must be provided in one voice band then speed must be sacrificed.

INPUT AND OUTPUT CIRCUITS

TONE EQUIPMENT for industrial applications is characterized largely by the circuits for modulating the transmitter and the circuits for transforming the output of the receiver demodulator (discriminator) into the desired output voltage or relay operation. It is the fine points of these circuits that are largely responsible for the attainment of the high degree of reliability that many of these industrial functions require. It is in the design of these circuits that considerable profit has been derived from experience with frequency-shift power-line carrier-current equipment as it has been possible to use circuits which are similar if not identical to those employed in the power-line carrier equipment designed for that same function.

The transmitter modulation is accomplished by using a germanium diode as a switch (diode switch modulator) to connect a reactive component (capacitor) across part of the oscillator tuned circuit in order to accomplish the desired frequency deviation. A very similar circuit is employed in the power-line carrier equipment (30 to 200 kc crystal controlled) and in both cases it has been found to provide a high degree of long-term stability and proper modulation with a wider range of modulating voltage and waveshape. By this means either voltage or contact keying are provided easily. This circuit also makes it possible to provide a single transmitter design for all the various functions listed with the exception of load control where both RAISE and LOWER indications are transmitted over a single tone channel. This load control scheme will be discussed in greater detail in later paragraphs.

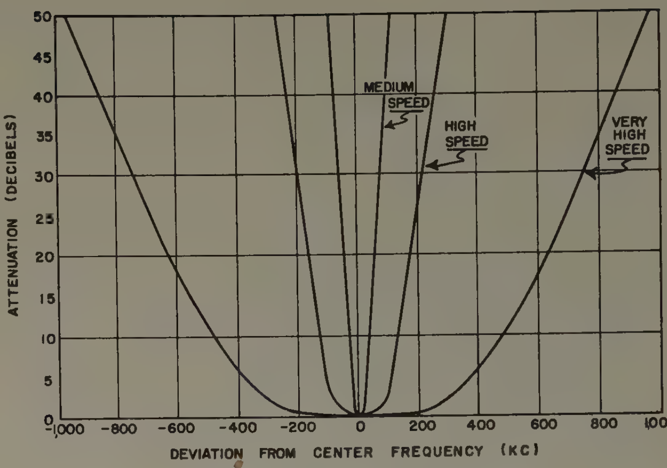

Fig. 1. Typical selectivity curves

Table I

	Medium Speed	High Speed	Very High Speed
Frequency range (cps)	420–2,580	1,620–7,380	2,500–17,820
Frequency spacing (cps)	120	360	2,000– 1,080 depending on the frequency
Speed of operation (ms)		10	3
Keying speed (cps)	37	90	
Frequency shift (cps)	±30	±90	±250–270
Function			
Teletype and telegraph	X	X	X
Telemetering	X	X	X
Transfer-trip (transformer bank protection)	X	X	X
Load control	X	X	X
Dialing and ringing	X	X	X
Supervisory control		X	X
Transfer-trip (line relaying)			X
Directional comparison relaying			X
Phase-comparison relaying			X

The receiver output circuits, on the other hand, vary appreciably with the various functions as it is necessary to furnish only a voltage output in some cases and in others to operate either one or two relays. There results from this requirement five varieties of receivers which, to facilitate manufacture, vary only by an adaptor panel which contains those circuits necessary to convert the discriminator output to the desired voltage or current. Relays, where necessary, are placed on a separate panel and do not appear in the receiver assembly proper. A description of the important variations in these five circuits follows:

1. *Telemetering, Teletype, and Control.* Many functions such as impulse duration telemetering, ringing, dialing, Teletype, telegraph, and supervisory control require the operation of a single relay. These functions as well as frequency-type (high-speed) telemetering all may be performed using the same basic receiver output circuits. For frequency-type telemetering, to be sure, an output voltage of frequencies below 35 cps is required rather than a relay operation, but it has been found that the relay tube stage can be used very satisfactorily as an amplifier of the low-frequency telemeter signal. For these functions the circuits differ little from conventional Teletype equipment circuits, the changes being those required to provide the necessary flexibility.

For example, a link is provided in series with a capacitor connected to the grid of the relay tube so that it easily may be disconnected from the circuit if the application is for space-code supervisory control. The function of this capacitor for all other applications is to provide an extra margin of operation in the presence of impulse noise by providing a slight time delay, but for the high-speed supervisory function this delay is found to be undesirable. Also, for frequency-type telemetering, a second link is provided so that a blocking capacitor may be inserted in series with the grid of the tube so as to block the d-c component of the voltage output from the discriminator which otherwise might change the bias voltage of the amplifier and thus its gain and operating point. In addition a third link is provided to permit an output voltage potentiometer to be inserted so that the voltage output may be adjusted to any desired level for frequency-type telemetering.

As previously explained, wherever relays are to be used they are mounted on a separate panel. For Teletype or telegraph these may be biased polar relays if desired. In order to co-ordinate the output stage with the relay requirements, provision is made to adjust the grid bias so as to control the residual relay current and also terminals are provided for the addition of extra series resistance for use with low-resistance relays to avoid exceeding the plate dissipation rating of the relay tube and still provide the desired relay coil current.

2. *Directional Relaying and Transfer-Tripping.* These functions require very high speed operation and, of course, exceedingly high reliability. In all cases a TRIP and a GUARD (or ALARM) relay must be operated and thus the receiver output circuit must contain two relay tubes, the plate current of one being used to energize one of the relays when the high-shift frequency is received and the other being used to energize the other relay when the low-shift frequency is transmitted. The problem of designing the circuits of these relay tube stages is complicated because the relays are furnished as a part of the relaying equipment and their contact rating and other design features in turn must be co-ordinated with the switchgear that the channel ultimately must operate. As an example, it is required that the residual relay current in the de-energized relay (particularly the TRIP relay) be very small, much lower than would be tolerated in applications where reliability is not of such paramount importance. This requirement implies the use of a high fixed bias on the relay tubes. On the other hand, when the relays are to be energized the relay current must be well over the pickup value. Thus, the relay tubes must have a much higher plate current rating than for other applications and must be driven well into saturation to furnish this high value of current reliably and consistently.

Fig. 2. A frequency-shift audio-tone receiver unit partly withdrawn from its cover for servicing and adjustment

Another circuit refinement for transfer-trip includes an automatic safety feature which guards against false operation of the channel by noise in cases of loss of received signal. This loss of received signal may be the result of either loss of tone-transmitter output or failure of the path of transmission, such as a microwave channel or a pair of wires, etc. This safety feature is accomplished in inserting a rectifying circuit between the grid of the TRIP relay tube and the discriminator which changes the random output of the discriminator into a negative bias voltage, thus guarding against false operation. A small amount of operating time is necessarily added by this protective circuit. This delay is tolerable on transfer-trip applications, but generally cannot be allowed for high-speed directional relaying.

3. *Phase-Comparison Relaying.* The function of phase-comparison relaying requires that the output circuit of the tone receiver be co-ordinated with a comparer tube stage similar to the equivalent stage in carrier-current phase-comparison relaying equipment. This comparer is mounted on a separate panel primarily because circuits from the station battery connect to the elements and it becomes easier to meet the high-potential test requirements for such circuits. The comparer stage must be co-ordinated properly with the phase-comparison relaying equipment. The channel itself must be exceedingly high speed in operation as very little phase shift can be tolerated in accomplishing the phase-comparison function.

4. *Load Control.* Some types of load control require the transmission of RAISE, LOWER, and HOLD functions. The RAISE function may be obtained by transmitting the high-shift frequency so as to energize one relay, and the LOWER function by the low-shift frequency so as to energize another relay, while for the HOLD function neither of the relays is energized. For the HOLD function, it theoretically is possible to transmit the center frequency so as to obtain zero output from the discriminator and by this means to hold both relays in the de-energized condition, but in practice this has not been found to yield the required degree of reliability as there are many conditions of abnormal channel operation that can cause the discriminator output to be other than zero and thus to transmit a false RAISE or LOWER indication. Such false operation must be avoided carefully.

In the design of these tone units a scheme has been employed that has been used very successfully in frequency-shift carrier-current equipment for some time, and which inherently possesses a high degree of reliability. This scheme is as follows:

The modulator of the transmitter is preceded by a multivibrator circuit which, in effect, causes the transmitter frequency to shift back and forth between the high-shift and the low-shift frequencies at approximately a 20-cps rate, when the HOLD function is to be sent. To transmit either the RAISE or the LOWER function the multivibrator circuit is biased so that it is held steady in order that either the high-shift or the low-shift frequency alone is transmitted.

In the receiver the discriminator output circuit contains a time delay circuit which prevents the keying voltage applied to either relay tube from reaching an appreciable value unless the output has a steady polarity for approximately 0.1 second. In addition there is a germanium diode detector which rectifies any a-c component from the discriminator output and uses voltage generated to provide additional bias to the relay tubes so as to yield a further margin of safety against false operation. This same germanium diode detector circuit also functions, in the event of channel failure, to rectify any fluctuating voltage output (or noise voltage) from the discriminator and to apply the resulting direct voltage to bias the relay tubes so as to add to their margin of safety against false operation. This is important in both carrier-current and microwave applications as channel failure frequently results in the application of high r-f or audio noise levels to the input of the load control receiver. This in turn results in a high level of fluctuation output voltage from the discriminator stage.

Note that with this scheme there is no motion involved except for the output relay operation when the RAISE and LOWER functions are being received. The HOLD function is accomplished electronically and thus does not cause any more wear on any part than does the quiescent state.

PHYSICAL DESIGN

AUDIO-TONE EQUIPMENT, the design of which is slanted toward industrial applications, will be unique also in several physical respects. For one thing the existence of only a few terminals at each location, plus the demand for the utmost in reliability generally makes it advisable to have each transmitter or receiver stand operate independently particularly in that each should contain its own power unit. The provision of a self-contained power supply is most economical where a small number of channels is involved and is most flexible in any case. Also, power supply difficulty then cannot cause the failure of more than one channel.

As already has been made clear, the extremely wide variety of applications for which this equipment may be applied at each station affects greatly the layout of the output circuits. It also implies that the means of servicing and repair of a channel necessarily must be very convenient as it becomes impractical to use the method of substituting a spare channel for one that is not operating properly. Instead, "on the spot" servicing and adjustment must be provided readily. To accomplish this the units, each of which occupies one standard rack unit of space, are designed in a drawerlike arrangement. The cover of the unit is fastened firmly to the rack for mounting and the unit can be drawn out readily by simply unfastening the speed fastener on each side and pulling it forward. This action permits easy access to all components and adjustments for the channel. This physical design is illustrated in Fig. 2. A typical assembly of units is shown in Fig. 3.

Connections are made to the rear of the chassis by a plug and receptacle with adequate slack in the cable to permit the unit to be drawn out far enough to permit the plug to be disengaged or re-engaged. This permits the removal of the unit from the rack entirely without the need for access to the rear of the chassis.

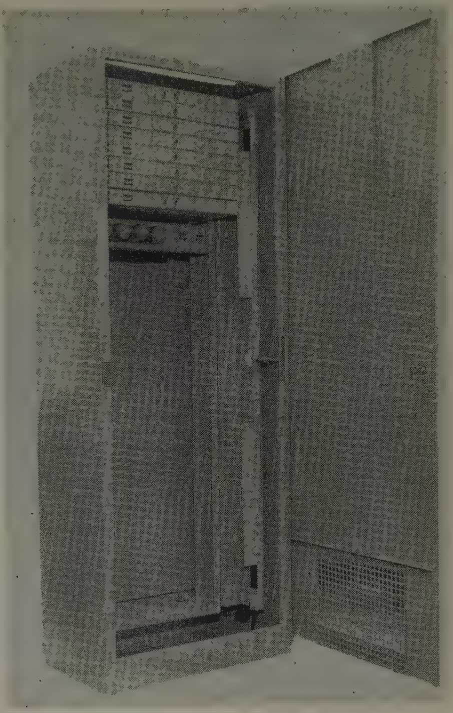

Fig. 3. Assembly of six audio-tone transmitters, two receivers, and an external relay panel as used for telemetering, load control, and ringing over an FM microwave channel

CONCLUSIONS

INDUSTRIAL APPLICATIONS of audio-tone equipment impose a number of unique requirements on the design of such equipment. The execution of the design of the tone equipment described has been made much easier by extracting many of the fine points of carrier-current equipment designed for these same functions and developed over a period of many years' experience in the carrier-current field.

The circuits thus employed are conventional, tried, and proved for the most part in the field of power-line carrier current. Likewise, the application of the high-reliability tube types is a feature which has proved most desirable for industrial applications. In short, these designs have been executed with high reliability kept foremost in mind so as to bring to the ultimate user a service at the lowest possible total cost.

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A UHF Transmitter Employing Klystron Power Amplifiers

W. H. SAYER

The development of practical useful power in the uhf band was made possible through the use of the high-powered cascade klystron amplifier. This amplifier is discussed here together with the transmitter, as this type of klystron is less well known. It was found to be the only tube using transit time to advantage which withstood the test of time in generating high power for all uhf channels in the frequency spectrum of 470 to 890 mc.

IN THE SEARCH for a high-power transmitting tube for the frequency range of 470 to 890 mc, it rapidly became evident that only a tube using transit time advantageously could solve the problem. In any discussion of a uhf transmitter employing a klystron power amplifier, a basic knowledge of klystrons is essential.

Since the klystron type familiar to many is the small low-powered reflex klystron oscillator, a review of the high-powered cascade klystron amplifier is given. The electron gun of the klystron concentrates the beam to approximately the size of the diameter of the drift tube opening. The electrons receive their acceleration from the beam power supply. The electron beam enters the drift tube, then proceeds down the drift tube, and is kept from spreading by the axial magnetic field. When the electrons reach the first gap, they are either accelerated further or decelerated by the r-f voltage set up by the first tuned circuit. By the time these electrons are at the second gap, they have had a chance to form discrete bunches. The electron bunches excite the second tuned circuit improving the "bunching" and increasing the gain of the klystron. The electron beam is in the form of bunches by the time of arrival at the output gap. The output gap must present the correct impedance to transfer effectively all the r-f power from the final bunched beam to the loaded cavity. The collector then dissipates the remaining power of the electron beam and is usually water cooled.

This general type of tube has been used previously in wide-band operation in France[1] and the United States. Because the early tubes have cavities in the vacuum system, their method of tuning has been to change the gap spacing in the drift tubes. The only commercial tubes available with demountable cavities outside the vacuum system are the Eimac klystron series type *3K20,000LA, LF, LK.* The demountable cavities allow considerable tuning range (720 to 890 mc on the *3K20, 000LK*) without

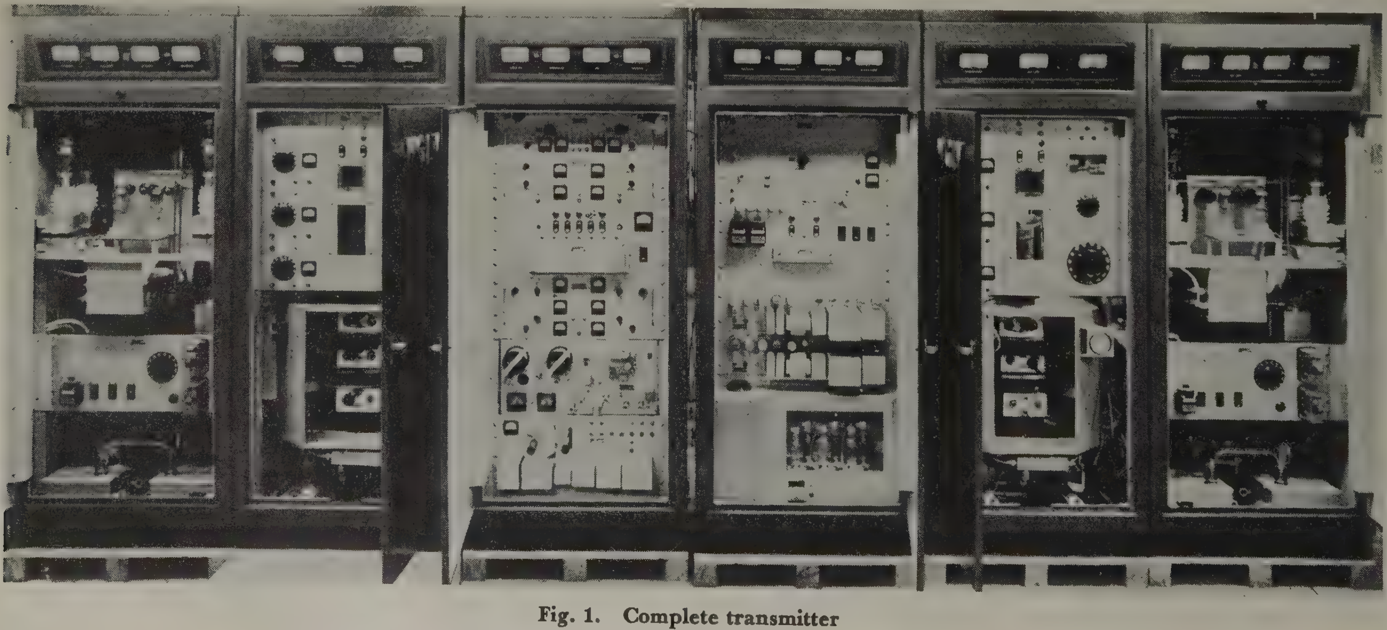

Fig. 1. Complete transmitter

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The author wishes to express his sincere appreciation for the help and inspiration of W. W. Eitel, J. A. McCullough, and the Research Division at Eimac without whom the development of this transmitter would not be possible, as well as to all those associated with the project at Allen B. Du Mont Laboratories, Inc.

changing the gap spacing and allow the designer to have control of the external tuned circuits for his application.

Fig. 1 shows the 5-kw Du Mont transmitter with the front doors open, designed for use with the klystrons. The two center frames are for the exciter and modulated amplifier. The sound channel klystron and power supply are on the left and the visual channel klystron and power supply on the right. The high-voltage power transformers, variable-voltage transformers, side-band filter, diplexer, and heat exchanger are installed external to the frames. Fig. 2 is a block diagram of the system. The frequency control for both visual and aural transmitters is shown in Fig. 3. The frequency modulation of the aural oscillator is produced by a reactance tube. A second reactance tube controls the average frequency of the oscillator and the control voltage for this tube is derived from a crystal discriminator.[2] Two dividers locked to the FM oscillator drive the crystal discriminator. The stabilized FM oscillator output is doubled, then mixed with the visual crystal oscillator frequency. The exciter output frequencies are 91.718 mc for sound and 60.77 mc for visual for a channel *57* transmitter. The aural exciter frequency then is multiplied by 8 with three doublers using *4X150G*'s and the visual exciter frequency multiplied by 12 with one tripler and two doublers.

The visual overtone crystal operates at approximately 20.25 mc and any drift in this crystal oscillator frequency also changes the aural frequency. However, the difference (4.5 mc) is dependent upon the stable crystal discriminator operating at a low frequency.

The final visual frequency doubler drives the modulated amplifier which is shown in Fig. 4. This circuit is a grounded grid type as far as radio frequency is concerned but is grid modulated with video. The plate circuit is a waveguide resonator with capacity output coupling. The video modulation from a low-impedance cathode follower modulator is applied to the grid through a small r-f choke. The r-f drive is applied to the grid-cathode tuned circuit by a coupling loop fastened to the sliding short. Because the grid of the tube has a long electrical length at 730 mc, it is necessary to tune the grid to ground with a one-half waveline. This modulated amplifier is stable and with the effective grid to ground impedance slightly inductive, the linearity is improved considerably as shown in Fig. 5.

The final linear amplifier is the Eimac klystron tube type *3K20,000LK* as shown in Fig. 6. One of the demountable cavities is shown fastened on the output gap. The movable end tuning plungers have been removed to show the method of cavity construction. Spring fingers which are fastened to the ring on the top of the cavity make contact to the 1/4-inch copper disks on the tube.

The basic circuit of the klystron used is shown in Fig. 7. The filament is a source of electrons and these electrons are accelerated to the cathode by the bombarder supply. This cathode is the source of electrons for the electron gun of the klystron and is made of tantalum. The tantalum button or cathode requires about 1,200 watts to emit electrons. The electrons then are accelerated to the anode in a modified pierce gun design by the high-voltage beam supply. An auxiliary or prefocus magnetic circuit is used to center the beam in the drift tubes and to increase the over-all efficiency of the tube. After the beam of high-energy electrons enters the drift tube, a magnetic circuit keeps the electron beam from spreading. Any klystron amplifier tube must have an excellent vacuum to prevent gas focusing, as the operation of a gas focus tube is quite erratic and unpredictable. The magnetic field

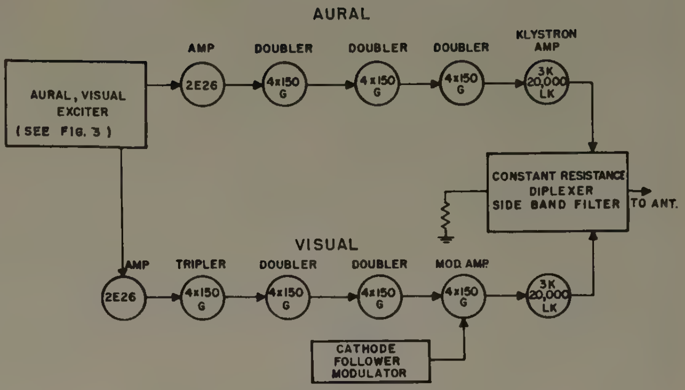


Fig. 2. Block diagram of the system

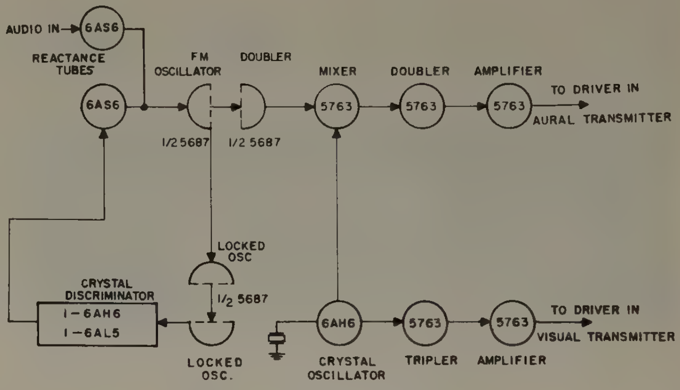


Fig. 3. Aural and visual exciter

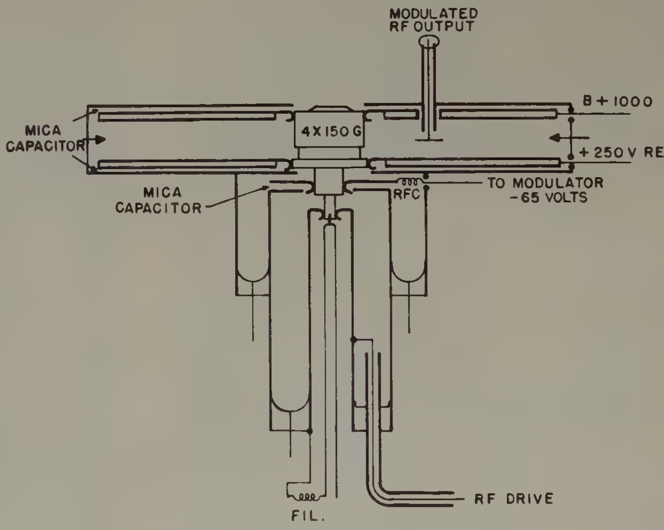


Fig. 4. Modulated amplifier

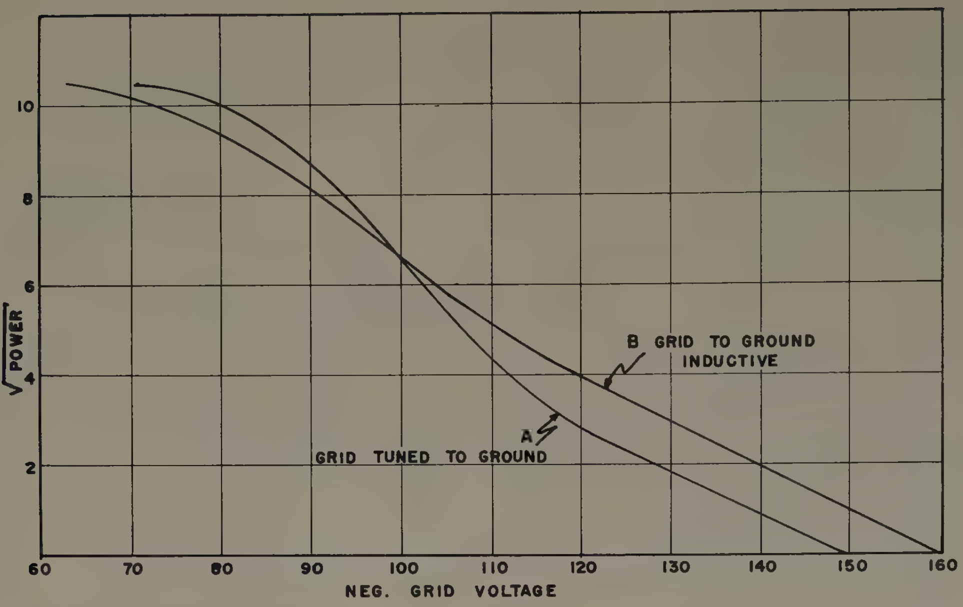


Fig. 5 (left). Linearity of modulated amplifier

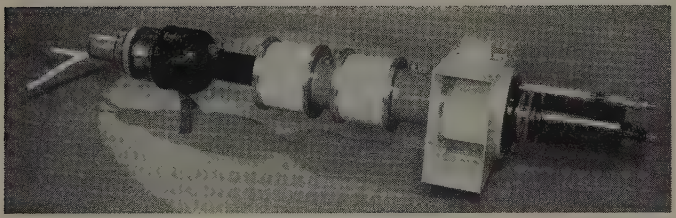


Fig. 6. Klystron and output cavity

increases from about 110 gauss at the top pole to about 190 gauss at the bottom pole piece. This field is obtained by the two large coils with 1,400 turns with a direct current of 2 amperes and the bottom coil with 1,800 turns at 0.8 ampere. A plot of field versus length of drift tube is shown in Fig. 8 with positions of magnetic coils and gaps. The iron frame saves on d-c power because it completes the magnetic return path. The normal cavity current with the magnetic field adjusted properly is between 0.05 and 0.1 ampere. The cooling of the drift tubes requires a water flow of 1 gallon per minute and the collector requires 8–10 gallons per minute.

The beam supply is a 3-phase full-wave bridge supply with a variable-voltage transformer for voltage control up to 14,000 volts. This supply has a 2-section filter to reduce ripple due to line unbalance to prevent amplitude modulation of the beam. A single 3-phase full-wave bridge supply is used to get rid of "spiking" due to the start of mercury-vapor rectifier conduction. The beam supply has a total current overload, and a cavity current overload in case of failure of the magnetic circuit. Both of these circuits are protected by thyrite elements as the so-called ground bus can approach beam voltage as a transient in case of short circuits at these voltage levels. A 37-ohm transient suppressor also is included in the high-voltage supply. The cathode is heated by a single-phase full-wave supply with a single section filter delivering about 2,000 volts at 0.6 ampere. This bombarder supply has to be well insulated because the anode of the klystron is grounded and, therefore, the supply is negative with respect to ground by the amount of the beam voltage.

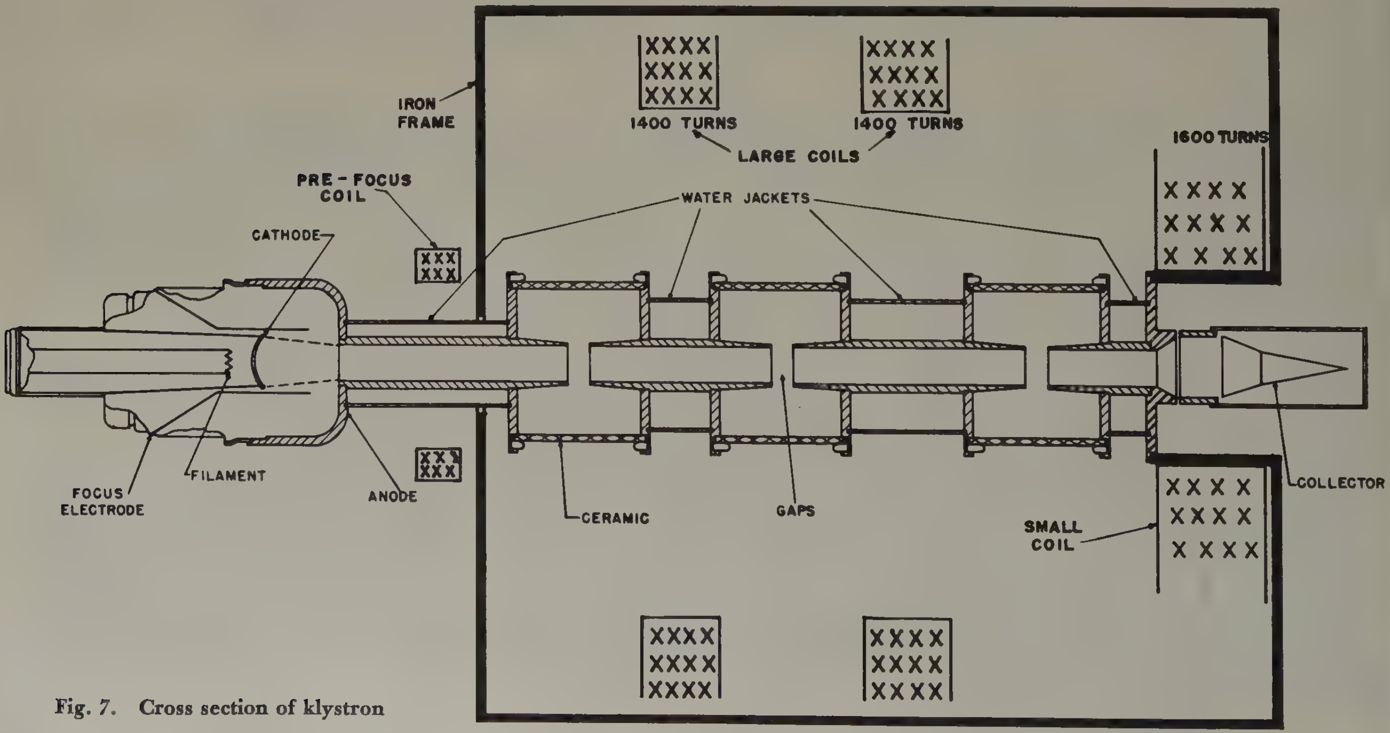


Fig. 7. Cross section of klystron

Fig. 9 shows the final assembly of the klystron with the cavities assembled and water plumbing assembled.

Having covered the mechanical aspects of the klystron, the next concern is with using the klystron as a broad-band amplifier. The input and center circuits are normally quite narrow and some thought must be given to broadbanding the amplifier.

The design of the first circuit in the klystron amplifier was made to accomplish maximum efficiency for a 5-mc bandwidth. In this design two requirements must be met:

1. It is necessary to have a reasonably flat load on the upper side-band frequencies for correct operation of the video-modulated amplifier.
2. It is necessary to have the maximum voltage across the first gap for velocity modulation of the electron beam for a given amount of drive power.

The input circuit is a double-tuned overcoupled transformer with a step-up ratio. Fig. 10 shows the mechanical construction. The inductive iris for controlling the coupling between the two tuned circuits is visible. The electron loading of the first gap was found to be quite small allowing the main damping on the high-voltage side of the transformer to be a coupling loop terminated in a 50-ohm wattmeter. The voltage standing wave ratio at the input terminal was better than 1.2 to 1 from 1 mc below to 4 mc above carrier frequency.

The center circuit on the middle gap also must have enough bandwidth. This circuit is a double-tuned overcoupled transformer similar to the input circuit. However, external damping is used on the low-voltage side of the transformer as the electron loading due to the beam is small on the high-voltage side.

The output circuit is a single-tuned circuit with an adjustable coupling loop in $3^{1}/_{8}$-inch coaxial line shown in Fig. 11. The output circuit is broad enough for video use. In a theoretical investigation,* it was shown that the output *Q* on the last tuned circuit for maximum output would be about 70–100 at 730 mc. Experimentally, the output *Q* needed for maximum output was 64 or a 3-db bandwidth of 11.4 mc at 13-kv beam voltage and as the beam voltage is increased, the loading also must be increased. This bandwidth is ample for video use as a 4-mc side-band component would be about −2 db.

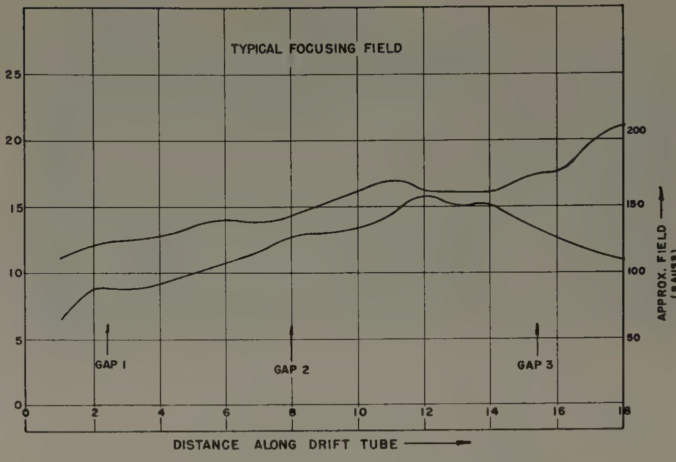
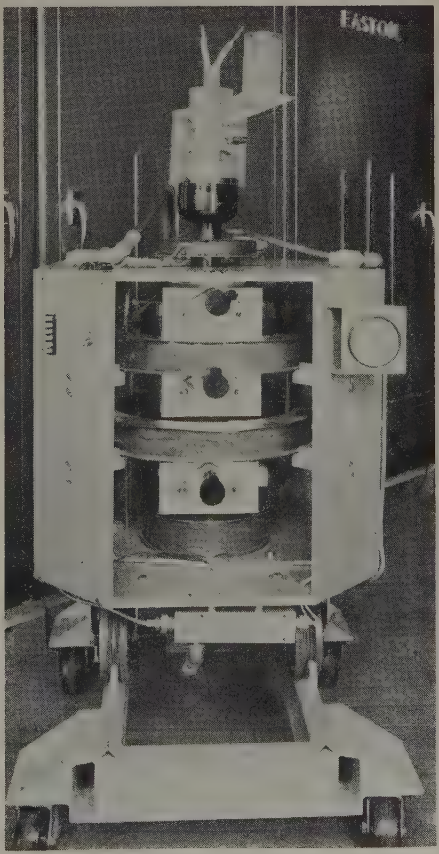
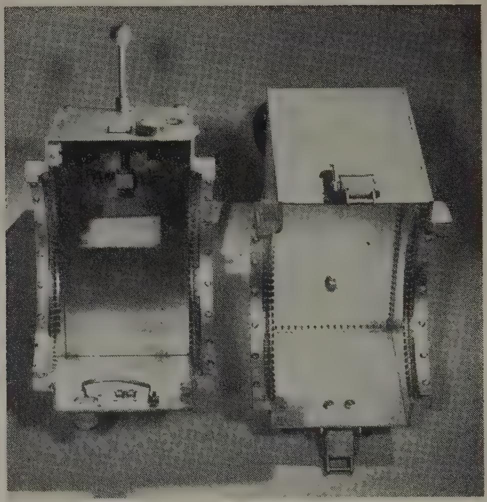


Fig. 8. **Typical focusing field**

In order to make the klystron amplifier flat over the passband, it is necessary to peak the center tuned overcoupled circuit 2 db at the high end. This can be done because the average power in these high-frequency side bands is down about −20 to −30 db compared to the side-band components near the carrier. The 3.58-mc components, when transmitting National Television System Committee color, are down about −20 db.

With the klystron delivering full power (continuous wave) in broad-band operation, a power of 300 watts is dissipated in the wattmeter connected to the center circuit. The amplifier requires about 50 watts total driving power under these conditions.





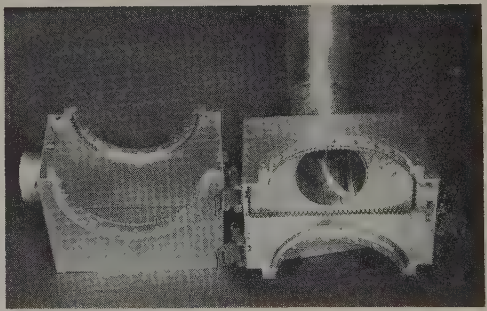


Fig. 9 (left). **Klystron assembly.** **Fig. 10 (top right).** **Double tuned circuit.** **Fig. 11 (bottom right).** **Output tuned circuit**

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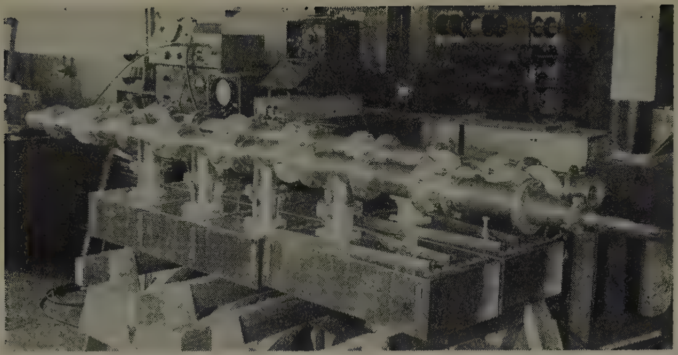
* W. Chesnut. Report No. *12.2.15/215*, Research Division Allen B. Du Mont Laboratories, Inc., Clifton, N. J.



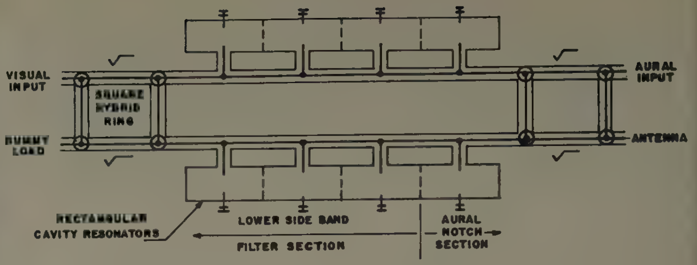


Fig. 12 (left). Diplexer and side-band filter. Fig. 13 (above). Schematic of uhf diplex and filter network

Circuit efficiency becomes more important in amplifiers used at ultrahigh frequencies. This determines the useful power output of the amplifier and the losses in the circuit. Correct design of by-passes and contact fingers in the uhf circuits become much more difficult due to the high circulating r-f currents at these frequencies. Circuit efficiency is

$$100\times\frac{Qu-Q_L}{Qu}$$

where Qu is the unloaded Q, and Q_L is loaded Q.

Of course, it is necessary to couple to the tuned circuit to measure Q and a correction must be made for this coupling.

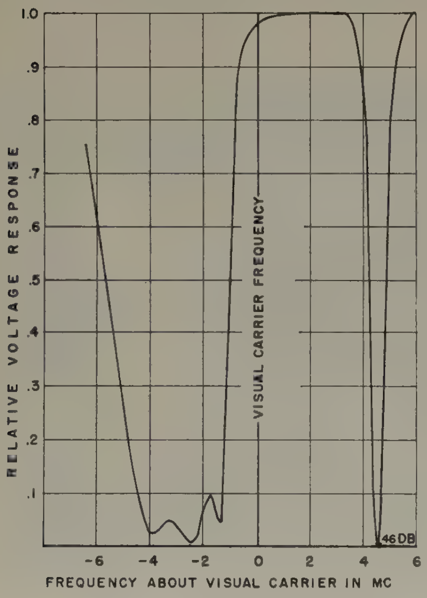
A Q measurement technique which corrects for the loading due to the coupling loop after the slotted line was used. The procedure outlined in the afore-referenced article is one of the most comprehensive on the measurement of unloaded Q of cavities. Use of the graphs in the report saves considerable time.

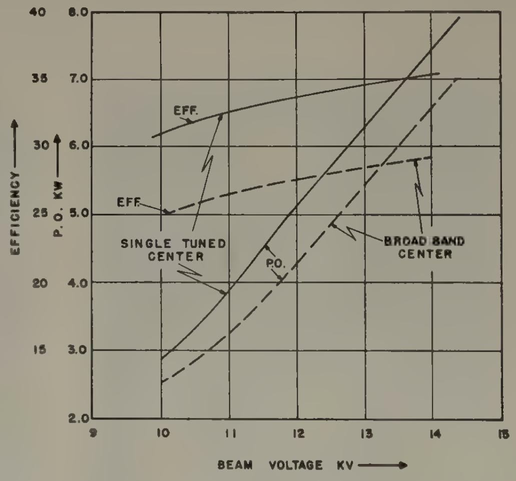
A comparison of circuit efficiency of a low-power tetrode and the klystron output circuit is shown in Table I. A typical tetrode is the *4X150G* used as a modulated amplifier to deliver 120 watts peak. The klystron can deliver 8 kw to the output cavity with only 175 watts lost in the output circuit including seals, ceramics, and copper losses.

The ceramic losses are less when the tuning plungers are closer to the ceramic windows near the high end of the tube frequency range where the unloaded Q is around 3,500.

The aural klystron amplifier is very similar with the exception of the center-tuned circuit which, in this case, does not have to be broadbanded and, therefore, is a single-tuned cavity. The Q of the single-tuned circuit is much higher and the gain of the klystron is much greater. However, the driver in the aural chain supplies much more power than needed so the broad-band double-tuned input circuit is used. This simplifies the spare tube problem, as this can be pretuned for video and used in either transmitter amplifier. The center circuit is tuned on the high side of resonance to reduce the power gain still further which also gives a slight improvement in efficiency.

A side-band filter is necessary to get the sharp cutoff on the lower side band and is combined with the diplexer. The diplexer is needed to combine picture and sound





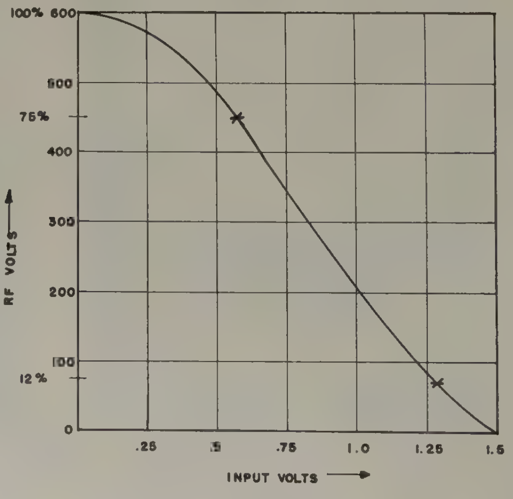


Fig. 14 (above). Frequency response curve of the diplexer and lower side-band filter with data taken at 730 mc. Fig. 15 (top right). Performance data for the klystron showing both the narrow-band power output and the broad-band power output. Fig. 16 (bottom right). The linearity of the visual system

Table I. Circuit Efficiencies

730 Mc

$$\text{Circuit Efficiency} = \frac{100\,(Qu - Q_L)}{Qu}$$

4×150 Tetrode	Klystron Amp
Eff. $= \frac{300-80}{300} = 73\%$	$\frac{3{,}000-64}{3{,}000} = 97.9\%$
Output C≅4.7 mmfd	Output C≅0.8 mmfd

without interaction into a single antenna feed line. This is shown in Fig. 12. The hybrid rings are 3/4-wave long on the arms and are shown schematically in Fig. 13. This combination† is a constant resistance device to present to the video transmitter a flat load at the sound rejection notches as well as at the side-band notches. The high Q cavities present short circuits at their resonant frequencies on the two transmission lines between the hybrid rings. Each pair of cavities is tuned to the same frequency so that the short circuits produced by the aural notch cavities reflect the aural-frequency power which add in phase at the antenna terminal of the hybrid ring. Likewise, the power in the lower side-band frequencies is reflected back into the dummy load. Of course, the 4.5-mc upper side band of the video transmitter is reflected back into the dummy load and not transmitted to the antenna.

The frequency response of the combined unit through the visual input to the antenna terminal is shown in Fig. 14. The side-band filter at uhf is not proportionally smaller than the equivalent filter at vhf, as it requires the same physical volume to achieve the lower side-band attenuation shown at both uhf and vhf. The sound-rejection filters are made of copper-clad invar waveguide to reduce temperature drift to a minimum.

The power output of the transmitter varies with the beam voltage and Fig. 15 shows the narrow-band power output and broad-band power output with a typical tube. In the theoretical investigation, it was shown that the power output and efficiency should be the same for broad-band or narrow-band operation. However, in broad-band operation of the center gap, the power gain would drop so that more r-f voltage at the input gap would be required for maximum bunching at the output gap for the same power output. This power gain did drop and the efficiency was less as shown on the data when 300 watts were dissipated in the center circuit's dummy load. However, data on the next transmitter installed have shown much less difference between the two methods of operation and with less power dissipated in the center-tuned circuits for the same bandwidth.

The linearity of the visual system is shown in Fig. 16. The modulated amplifier contributes all of the white compression at low power levels, and the klystron contributes the blacker-than-black compression at 8 kw. Less drive will reduce both the compression and the power output. In normal station operation, a stabilizing amplifier is used to set the synchronizing signal amplitude as a percentage of peak carrier.

The sound transmitter exciter measured about −60 db FM noise and, adding the klystron amplifier, it was still −60 db. Amplitude-modulation noise on the sound carrier measured approximately −50 db. The video transmitter and monitor receiver have a rise time of 0.12 microsecond with a 100-kc square wave.

REFERENCES

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2. A Simple Crystal Discriminator for FM Oscillator Stabilization. *Proceedings* Institute of Radio Engineers, New York, N. Y., vol. 39, no. 7, July 1951.

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† **J. M. De Bell, Jr.** Report *12.2.20/25*, Research Division Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

Radar Equipment Tests Strength of Radio Signals

New radar equipment which will tell how successfully broadcasts from long-range transmitters are reaching their destinations, has been announced by the Air Force's Air Research and Development Command.

The new device, COZI (communications zone indicator), also indicates approximately how strong the broadcast signals are when they get there and may show whether the enemy is deliberately jamming that particular frequency with static and interference.

COZI has been under development at Rome Air Development Center, Rome, N. Y., and at the Raytheon Manufacturing Company.

To test a radio signal, COZI sends out a radar beam from the station's own antenna. The beam follows the same path taken by the radio waves. The difference, however, is that the COZI beam comes back and tells where it has been, and often, whether it has run into any interference at its destination. The radar device is made in two units, each about the size of a steamer trunk. One is the transmitter, the other the receiver. To test a radio station, it is necessary to interrupt the broadcast momentarily while the radar beam is sent out. A reading is obtained instantly and broadcasting is resumed without any appreciable break or loss of time.

The Air Force plans to make extensive use of COZI to increase the efficiency and reliability of its world-wide communications system. Interest also has been displayed by the Voice of America, Radio Free Europe, and several large and powerful commercial radio stations in the United States, and by Canadian radio experts.

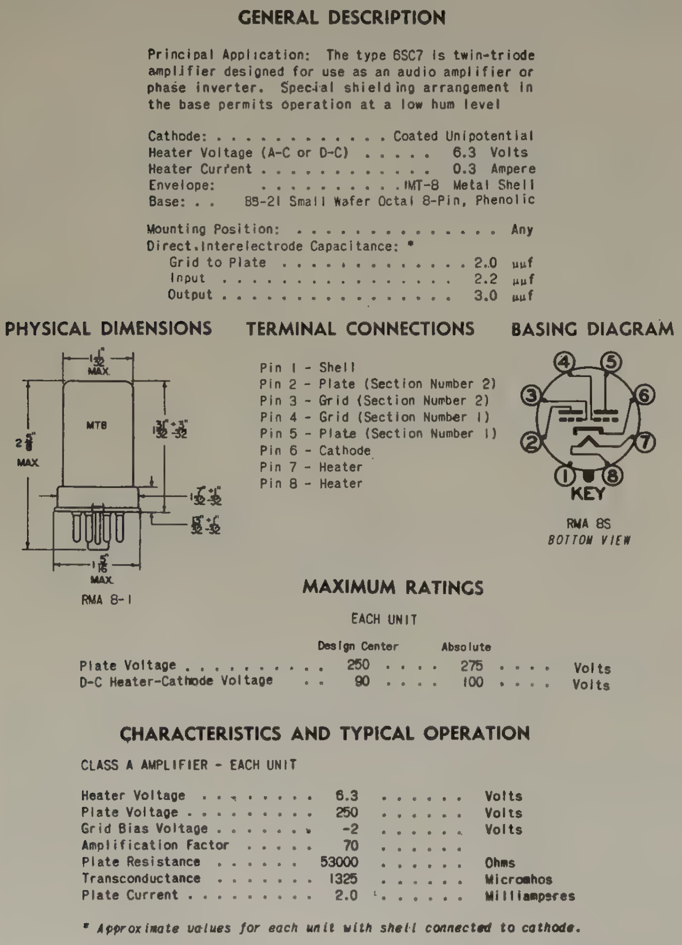
Large industrial and shipping concerns are studying the practicability of using the new radar as a standard accessory for long-range, directional radiobroadcasting equipment.

Transistor Application Fundamentals

R. F. SHEA

Tube and transistor circuits are compared, particularly as applied to audio circuits. Specifications for a 6SC7 tube and a 2N43 transistor are compared with emphasis on the distinctive features. A phonograph preamplifier is developed both for tubes and transistors to show the basic differences in the two circuits. Basic equations also are given for the two designs and their over-all characteristics compared.

WHILE a comparison of tubes and transistors is not the major objective of this article, it seems that one of the best ways to present the subject is to illustrate the design of typical circuits using both tubes and transistors. In this way the differences can be emphasized and the major design details brought out. Therefore, a preamplifier, such as used to follow a variable-reluctance phonograph pickup, was selected as a typical circuit. The signal levels are about ideal for either type of amplifier, and the necessary inclusion of low-frequency compensation provides an opportunity to illustrate the effect of the different impedance levels encountered with tubes and with transistors.


MT8
MAX
MAX
MAX
RMA 8-1
KEY
RMA 8S
BOTTOM VIEW

GENERAL DESCRIPTION

Principal Application: The type 6SC7 is twin-triode amplifier designed for use as an audio amplifier or phase inverter. Special shielding arrangement in the base permits operation at a low hum level

Cathode:	Coated Unipotential
Heater Voltage (A-C or D-C)	6.3 Volts
Heater Current	0.3 Ampere
Envelope:	MT-8 Metal Shell
Base:	B8-21 Small Wafer Octal 8-Pin, Phenolic
Mounting Position:	Any
Direct.Interelectrode Capacitance: *	
Grid to Plate	2.0 μμf
Input	2.2 μμf
Output	3.0 μμf

PHYSICAL DIMENSIONS

TERMINAL CONNECTIONS

Pin 1 - Shell
Pin 2 - Plate (Section Number 2)
Pin 3 - Grid (Section Number 2)
Pin 4 - Grid (Section Number 1)
Pin 5 - Plate (Section Number 1)
Pin 6 - Cathode
Pin 7 - Heater
Pin 8 - Heater

BASING DIAGRAM

MAXIMUM RATINGS

EACH UNIT

	Design Center	Absolute	
Plate Voltage	250	275	Volts
D-C Heater-Cathode Voltage	90	100	Volts

CHARACTERISTICS AND TYPICAL OPERATION

CLASS A AMPLIFIER - EACH UNIT

Heater Voltage	6.3	Volts
Plate Voltage	250	Volts
Grid Bias Voltage	-2	Volts
Amplification Factor	70	
Plate Resistance	53000	Ohms
Transconductance	1325	Micromhos
Plate Current	2.0	Milliamperes

* *Approximate values for each unit with shell connected to cathode.*

Fig. 1. Example of data supplied for 6SC7 general-purpose twin triode

In order to make a comparable beginning the *6SC7* tube was chosen for comparison with the type *2N43* p-n-p transistor. The former is used quite extensively for this purpose and is a representative tube triode. The *2N43* is the high-alpha transistor announced in 1953 by the General Electric Company, which is particularly well suited to this application, as the subsequent material will demonstrate.

As a beginning compare the specification sheets for the two. Fig. 1 is a reproduction of the data supplied for the *6SC7;* Fig. 2 gives the accompanying table of Class *A* resistance-coupled amplifier data, and Fig. 3 shows the plate characteristics, to which have been added two 50,000-ohm load lines. Fig. 4 shows the data released on the *2N43* transistor, and Fig. 5 shows the accompanying set of typical characteristic curves. Fig. 6 is a reproduction of the collector family with the addition of a load line, for comparison with Fig. 3. Fig. 7 shows an emitter family of curves.

One of the first impressions which is created by these data is the very considerable difference in the amount of them. There is only one characteristic curve presented for the tube, as against seven for the transistor. There is a similar disparity between the amount of performance data. This simply illustrates the fact that actually more quantitative material is already available about transistors than has been accumulated on tubes in all these years. The situation is complicated by the additional fact that many of the transistor characteristics are temperature sensitive. Lastly it must be admitted that much of the prevalent tube practice has developed along empirical lines and that most engineers have developed a "feel" for tube circuits. While this eventually will be true in the transistor application field, the subject is so complex that it is necessary to supply a very great amount of material at the present time.

Compare the static characteristics, as represented by Figs. 3, 6, and 7. In Fig. 3 two operating points have been shown, one at 250 volts, 2 milliamperes (ma), the other at 75 volts, 0.5 ma. For the first, a 50,000-ohm load line permits output swings of 135 volts, 2.7 ma. Power output is approximately 45 milliwatts. For the lower

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Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954.

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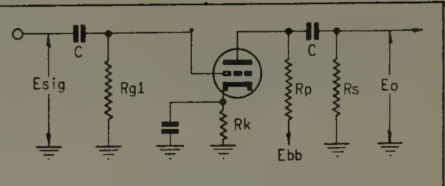
operating point swings are 44 volts, 0.9 ma, power output 5 milliwatts. Efficiency in the first case is 9 per cent, in the second 13 per cent. This does not include heater power, which totals 1.9 watts for the double triode.

By comparison, for the transistor, using a load line corresponding to 5,000 ohms, the obtainable swings would be approximately 40 volts, 8 ma, power output 40 milliwatts, efficiency approximately 50 per cent. This illustrates vividly the marked difference in power requirements of transistors and tubes. To get 40 milliwatts of output from the tube requires 1,450 milliwatts of total power, as compared to 80 milliwatts for the transistor, a saving of 18 to 1. Also evident from the foregoing is the difference in impedance levels, in this case 10 to 1.

EACH UNIT

Rp Meg	Rg1 Meg	Rs Meg	Ebb = 90 Volts			Ebb = 180 Volts			Ebb = 300 Volts		
			Rk	Gain	Eo	Rk	Gain	Eo	Rk	Gain	Eo
0.10	*	0.10	1800	19	6.0	910	25	18	680	29	32
0.10	*	0.24	2000	25	8.0	1000	29	24	750	34	42
0.24	*	0.24	3300	28	9.0	1800	35	23	1300	39	40
0.24	*	0.51	3600	33	10	2000	40	30	1500	42	51
0.51	*	0.51	5600	35	8.5	3000	43	27	2200	46	46
0.51	*	1.0	6200	38	12	3300	46	35	2400	49	55
0.24	10	0.24	0	29	7.5	0	36	23	0	39	44
0.24	10	0.51	0	33	10	0	41	30	0	43	55
0.51	10	0.51	0	36	9.5	0	44	26	0	46	51
0.51	10	1.0	0	40	12	0	48	36	0	50	62



Note: Coupling capacitors (C) should be selected to give desired frequency response. Rk should be adequately by-passed.

Notes: 1. Eo is maximum rms voltage output for five percent (5%) total harmonic distortion. 2. Gain measured at 2.0 volts rms output. 3. For zero-bias data generator impedence is negligible. *Value of Rgl is non-critical.

Fig. 2. Class A resistance-coupled amplifier data

Now analyze these characteristics briefly. First of all why so many in the case of the transistor? Actually there are only two, if a fair comparison to the one tube characteristic shown is made. These are the V_c-I_c and V_e I_e curves, the first corresponding to the V_p-I_p curves for the tube. There is no tube characteristic corresponding to the emitter family. The other set of transistor curves, for constant base current, is derivable from the first. However, since the emitter and collector currents are usually very nearly equal, the base current (which is their difference) ordinarily cannot be obtained graphically with sufficient accuracy.

The reason for the remaining number of curves is that practically all the important transistor parameters show considerable variation with operating point and with temperature. By comparison the plate resistance and μ of a tube do not vary anywhere nearly as much. For example, for the 250-volt point of Fig. 3 μ is 70. At 75 volts it is 65; r_p is correspondingly 53,000 and 68,000 ohms; g_m is 1,325 and 950. For a transistor making a similar change in collector current would produce a more than 3 to 1 change in some parameters. The temperature effect is largely absent in tubes because of its high internal ambient. In the transistor, however, there is little internal heating, hence its characteristics are very responsive to changes in external ambient.

Now for some typical amplifier circuits. Fig. 8A shows a single stage using one half of the *6SC7*, while Fig. 8B shows a corresponding transistor circuit. Bias for the tube is obtained by means of a resistor in the cathode circuit, adequately by-passed. For small signal operation this network frequently is omitted, with bias supplied by the tubes internal contact potential. There is comparatively little restriction on the value of the grid resistor r', and it is usually several megohms. The load resistor, r_l, may have a value from a few tens of thousands of ohms to several hundreds of thousands.

By comparison, in Fig. 8*B*, bias is obtained by means of a series emitter resistance and battery. Bias also may be obtained by eliminating these elements and supplying the base through a voltage divider across the collector battery, however such an arrangement is subject to considerable variation of operating point with temperature and is definitely inferior to the circuit shown. As compared to the tube circuit, the input resistor r' is limited also by temperature considerations, normally to a few tens of thousands of ohms, and the bias stability is improved as this resistance is kept down. The load resistor r_l is restricted also. Transistors, unlike tubes, maintain practically constant collector current even at zero collector volts; further, the collector current can be temperature sensitive unless the circuit is well stabilized. Consequently it is possible for the net collector voltage to drop to zero, or even reverse, if the collector resistor is too large. For this reason r_l is usually held to 10,000 ohms or less. Transformer coupling is more popular with transistors than with tubes because it permits low values of d-c resistance while obtaining adequate a-c impedances for maximum gain.

Equivalent circuits are very valuable aids in visualizing the operation of devices in typical arrangements. Figs. 9*A* and 9*B* give the corresponding equivalent circuits for the two devices. The interelectrode capacitances have been omitted from these circuits for simplicity.

The comparative complexity of the two devices is readily apparent from this figure. The tube has a relatively simple circuit, is unilateral, its input resistance is that of the grid resistor r' (at low frequencies), its output resistance is the r_p of the tube. By contrast the transistor is bilateral, hence its input impedance is a function of the load and its output impedance is a function of its source. Further, as mentioned before, the parameters of the tube are relatively constant, while those of the transistor vary greatly with operating point and with temperature. In addition, both tube and transistor vary to some degree in production.

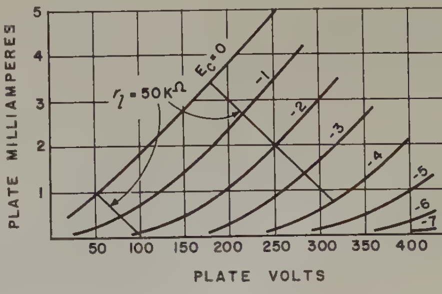


Fig. 3. 6SC7 plate characteristics with 50,000-ohm load lines

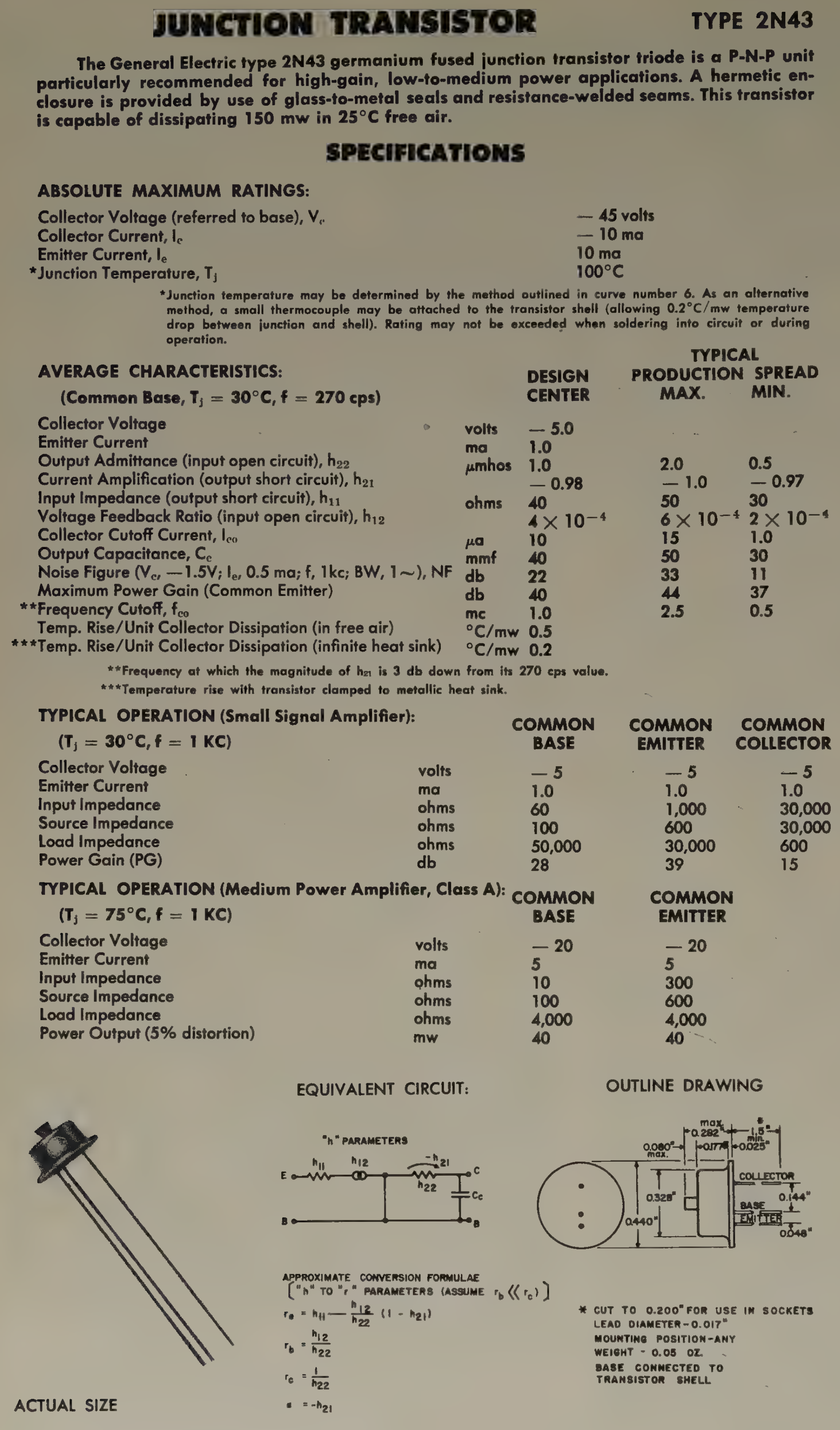


Fig. 4 (left). Example of data released for the 2N43 transistor

JUNCTION TRANSISTOR

TYPE 2N43

The General Electric type 2N43 germanium fused junction transistor triode is a P-N-P unit particularly recommended for high-gain, low-to-medium power applications. A hermetic enclosure is provided by use of glass-to-metal seals and resistance-welded seams. This transistor is capable of dissipating 150 mw in 25°C free air.

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS:

Collector Voltage (referred to base), V_c	— 45 volts
Collector Current, I_c	— 10 ma
Emitter Current, I_e	10 ma
*Junction Temperature, T_j	100°C

*Junction temperature may be determined by the method outlined in curve number 6. As an alternative method, a small thermocouple may be attached to the transistor shell (allowing 0.2°C/mw temperature drop between junction and shell). Rating may not be exceeded when soldering into circuit or during operation.

AVERAGE CHARACTERISTICS:

(Common Base, T_j = 30°C, f = 270 cps)

		DESIGN CENTER	TYPICAL PRODUCTION SPREAD MAX.	TYPICAL PRODUCTION SPREAD MIN.
Collector Voltage	volts	— 5.0		
Emitter Current	ma	1.0		
Output Admittance (input open circuit), h_{22}	μmhos	1.0	2.0	0.5
Current Amplification (output short circuit), h_{21}		— 0.98	— 1.0	— 0.97
Input Impedance (output short circuit), h_{11}	ohms	40	50	30
Voltage Feedback Ratio (input open circuit), h_{12}		4×10^{-4}	6×10^{-4}	2×10^{-4}
Collector Cutoff Current, I_{co}	μa	10	15	1.0
Output Capacitance, C_c	mmf	40	50	30
Noise Figure (V_c, —1.5V; I_e, 0.5 ma; f, 1kc; BW, 1~), NF	db	22	33	11
Maximum Power Gain (Common Emitter)	db	40	44	37
**Frequency Cutoff, f_{co}	mc	1.0	2.5	0.5
Temp. Rise/Unit Collector Dissipation (in free air)	°C/mw	0.5		
***Temp. Rise/Unit Collector Dissipation (infinite heat sink)	°C/mw	0.2		

**Frequency at which the magnitude of h_{21} is 3 db down from its 270 cps value.

***Temperature rise with transistor clamped to metallic heat sink.

TYPICAL OPERATION (Small Signal Amplifier):

(T_j = 30°C, f = 1 KC)

		COMMON BASE	COMMON EMITTER	COMMON COLLECTOR
Collector Voltage	volts	— 5	— 5	— 5
Emitter Current	ma	1.0	1.0	1.0
Input Impedance	ohms	60	1,000	30,000
Source Impedance	ohms	100	600	30,000
Load Impedance	ohms	50,000	30,000	600
Power Gain (PG)	db	28	39	15

TYPICAL OPERATION (Medium Power Amplifier, Class A):

(T_j = 75°C, f = 1 KC)

		COMMON BASE	COMMON EMITTER
Collector Voltage	volts	— 20	— 20
Emitter Current	ma	5	5
Input Impedance	ohms	10	300
Source Impedance	ohms	100	600
Load Impedance	ohms	4,000	4,000
Power Output (5% distortion)	mw	40	40

EQUIVALENT CIRCUIT:

OUTLINE DRAWING

APPROXIMATE CONVERSION FORMULAE
["h" TO "r" PARAMETERS (ASSUME $r_b \ll r_c$)]

$$r_e = h_{11} - \frac{h_{12}}{h_{22}}(1 - h_{21})$$

$$r_b = \frac{h_{12}}{h_{22}}$$

$$r_c = \frac{1}{h_{22}}$$

$$\alpha = -h_{21}$$

* CUT TO 0.200" FOR USE IN SOCKETS
LEAD DIAMETER - 0.017"
MOUNTING POSITION - ANY
WEIGHT - 0.05 OZ.
BASE CONNECTED TO
TRANSISTOR SHELL

ACTUAL SIZE

While it is not the intent of this article to delve deeply into the mathematics of the transistor, it seems apropos to give the basic equations for input and output impedance and the current and voltage amplification for the tube and transistor to illustrate further the comparison.

In Table I transistor equations $\Delta^h = h_{11}h_{22} - h_{12}h_{21}$. To add further to the complication there are three configurations in which transistors may be connected, just as there are cathode followers and grounded-grid amplifiers. Since it would be extremely complicated to provide the parameters for all three, together with their variations, the grounded-base parameters are given in the specification sheets, and conversion tables are provided. Thus the parameters for the grounded-emitter and the grounded-collector configurations may be obtained from the following equations.

Typical values of input resistance are in the megohms for the tube, about 50 ohms for the grounded-base transistor, 1,000 ohms for the grounded-emitter. Output resistances are about 50,000 for the tube, 20,000 to 2,000,000 for the transistor, depending upon configuration and terminal impedance. Current amplification of the tube is theoretically infinite, as is the power gain. Actually both are limited to finite values by the grid resistor. Current amplification for the transistor is approximately unity for the grounded-grid amplifier, about 30 to 100 for the grounded-emitter. Voltage amplification is about 50 for the tube, may exceed 1,000 to 2,000 for the transistor.

So much for the basic details, now to get down to the problem of designing a preamplifier. The requirements are as follows: input resistance 60,000 ohms; input signal 10 millivolts; output signal 1 volt; frequency response 18-db attenuation at 800 cycles, relative to 50 cycles; noise—50 db at 50 cycles.

Fig. 10 shows the circuit of a suitable tube preamplifier, which has been used for this purpose. As mentioned previously, the cathode bias networks have been eliminated. The first stage incorporates a filter section in the form of a 68,000-ohm resistor and 15 microfarads (μf.) capacitor. The effective load resistor of the first stage is 68,000 ohms, which is shunted by the effective impedance of the coupling network. The second grid connects to this network in such manner that the portion of the first plate voltage appearing on the second grid is attenuated as frequency increases, thus providing the desired frequency compensation. This second grid voltage is amplified and the amplified signal is taken off the second plate.

The over-all voltage amplification of the amplifier of Fig. 10 can be calculated in quite straightforward fashion by means of the equivalent circuit of Fig. 9*A*. The result of this calculation is

$$A_v = \left| \frac{\mu_1\mu_2 r_l}{r_l + r_{p2}} \left[\frac{z'}{r_{p1} + \dfrac{r_4 + z'}{1 + g'(r_4 + z')}} \right] \right|$$

where

$$z' = \frac{r_3(1 - j\omega r_2 C)}{1 - j\omega C(r_2 + r_3)}$$

and

$$g' = \frac{1}{r_l} + \frac{1}{r_{p1}}$$

Fig. 11 shows the basic circuit of the transistor stage with compensating network. Bias circuits have been omitted, except for r_3 which represents the a-c loading of the second stage bias resistor. As mentioned previously, the calculation of the performance of a transistor amplifier is complicated by the fact that the device is bilateral. Therefore we must start with the last stage and calculate the input impedance and amplification, using the equations of Tables I and II. Then we must combine this input impedance with that of the coupling network to obtain the load for the preceding stage, and then calculate its input impedance and amplification. This procedure must be repeated as many times as there are stages. The over-all amplification finally is obtained by combining the individual amplifications plus the attenuation in the coupling networks. This procedure has been followed for the 2-stage amplifier of Fig. 11 with the following result:

Over-all

$$A_v = \left| \frac{(h_{21})_1 (h_{21})_2}{\left[\Delta^h{}_1 + (h_{11})_1 \left(g' + \dfrac{1}{r_2 + \dfrac{1}{j\omega C}} \right) \right] [\Delta^h{}_2 + (h_{11})_2 y_l]} \right|$$

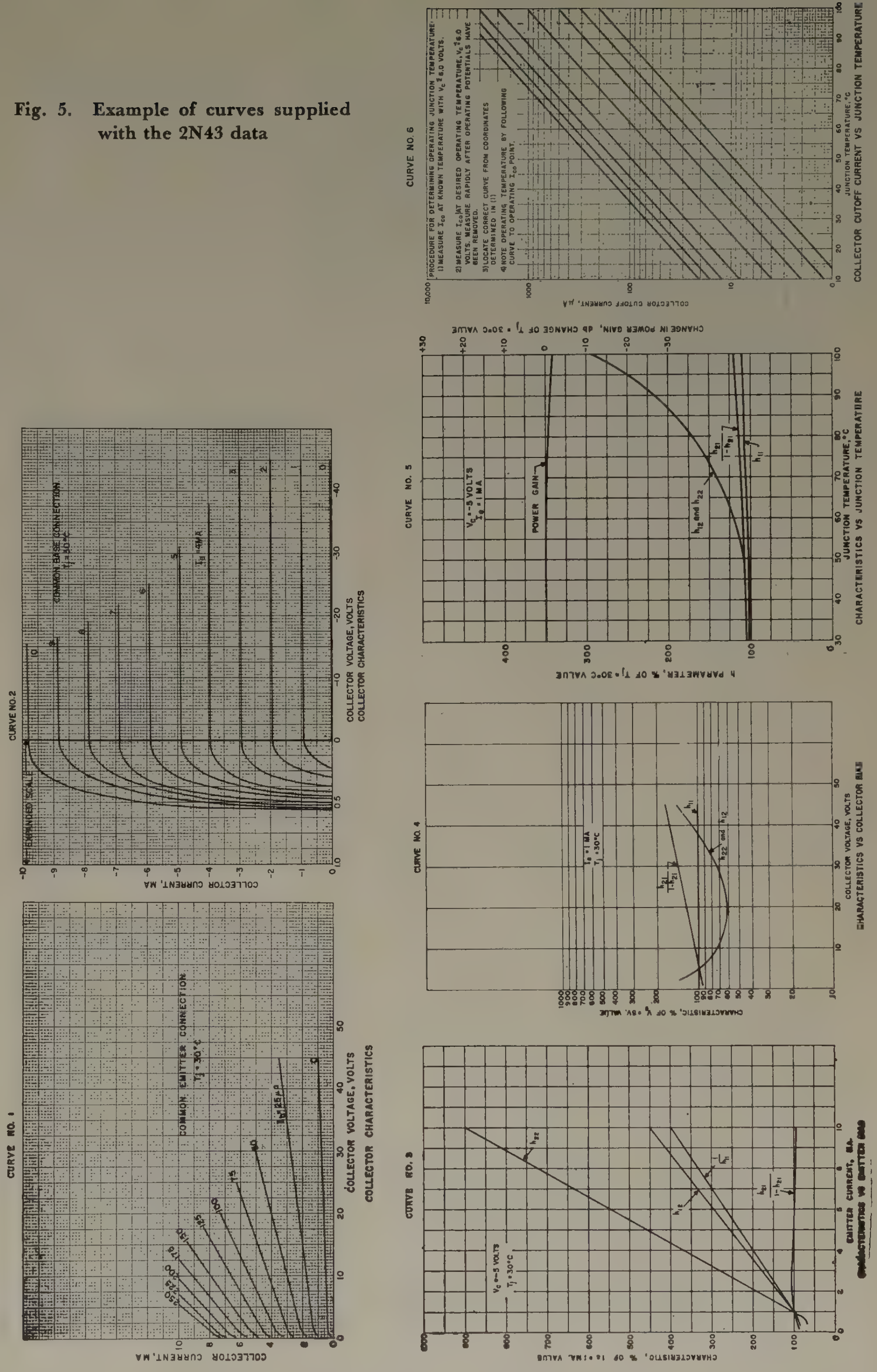
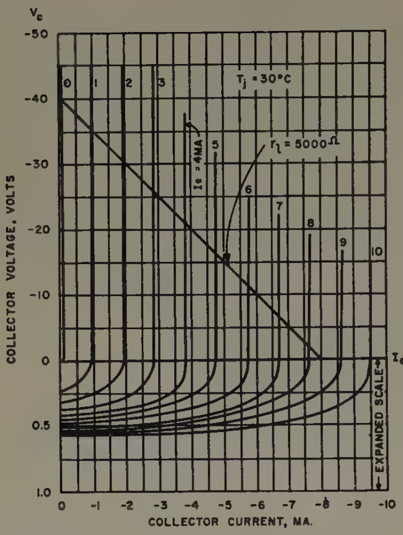


Fig. 5. Example of curves supplied with the 2N43 data



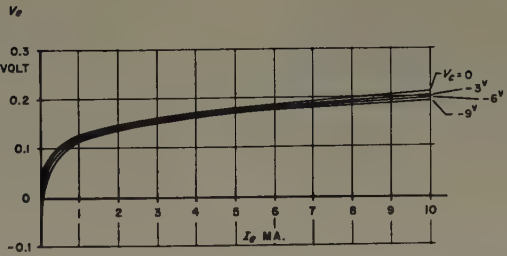
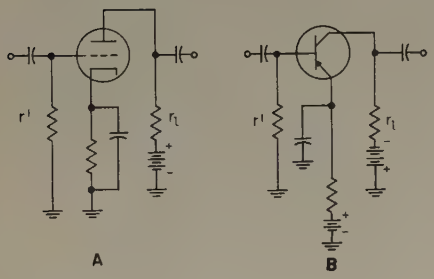


Fig. 6 (left). Collector family: grounded base configuration with a 5,000-ohm load line.
Fig. 7 (above). Emitter family



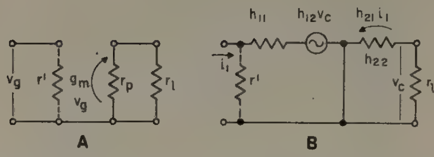


Fig. 8 (left). Typical amplifier circuits: A—tube circuit; B—transistor circuit.
Fig. 9 (above). Equivalent circuits: A—tube; B—transistor

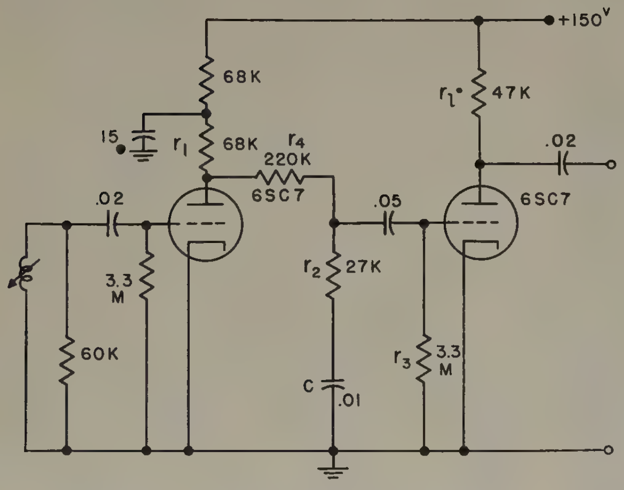


Fig. 10. Circuit of vacuum tube preamplifier

where

$$g' = \frac{1}{r_1} + \frac{1}{r_3} + \frac{1}{r_{i2}}$$

and

$$r_{i2} = \frac{\Delta^h{}_2 + (h_{11})_2 y_l}{(h_{22})_2 + y_l}$$

Fig. 12 shows the complete circuit of a 3-stage transistor amplifier constructed to have the desired performance. The various distinctive design features, as compared to those required for the tube amplifier, are given in the following.

One of the first features which will be noticed is the greater number of components required. Separate batteries are used for emitter and collector supplies, plus series resistors for each emitter. The resistors in the base and collector circuits have been held down to values much lower than those ordinarily employed with tube amplifiers. These features were dictated by the requirement that temperature stability be good, which, as mentioned before, necessitates these low values. Next, the values of all capacitors are much higher than those used in the tube amplifier, due to the lower values of impedance of the transistor amplifier stages. Similarly the compensating networks use large capacitance and small resistances, for example 1 μf and 470 ohms, as compared to 0.01 μf and 27,000 ohms. This, too, is due to the fact that the transistor stage input impedance is about 1,000 ohms, compared to 3 megohms for the tube amplifier. Further the low value

Table I.

	Tube	Transistor
Input impedance	r'	r' shunted by $\frac{\Delta^h + h_{11}y_l}{h_{22}+y_l}$
Output impedance	r_p	$\frac{h_{11}+z_g}{\Delta^h + h_{22}z_g}$ where z_g includes effect of r'
Current amplification	$\frac{g_m r_p r'}{r_p + r_l}$	$\left\lvert\frac{h_{21}y_l}{h_{22}+y_1}\right\rvert$ minus loss in r'
Voltage amplification	$\frac{g_m r_p r_l}{r_p + r_l}$	$\left\lvert\frac{h_{21}z_l}{h_{11}+\Delta^h z_l}\right\rvert$

Table II. Approximate Equivalences

Grounded-Base	Grounded-Emitter	Grounded-Collector
h_{11}	$h_{11}' \cong \frac{h_{11}}{1+h_{21}}$	$h_{11}'' \cong \frac{h_{11}}{1+h_{21}}$
h_{12}	$h_{12}' \cong \frac{\Delta^h - h_{12}}{1+h_{21}}$	$h_{12}'' \cong 1$
h_{21}	$h_{21}' \cong \frac{-h_{21}}{1+h_{21}}$	$h_{21}'' \cong \frac{-1}{1+h_{21}}$
h_{22}	$h_{22}' \cong \frac{h_{22}}{1+h_{21}}$	$h_{22}'' \cong \frac{h_{22}}{1+h_{21}}$
Δ^h	$\Delta^{h\prime} \cong \frac{\Delta^h}{1+h_{21}}$	$\Delta^{h\prime\prime} \cong \frac{1}{1+h_{21}}$

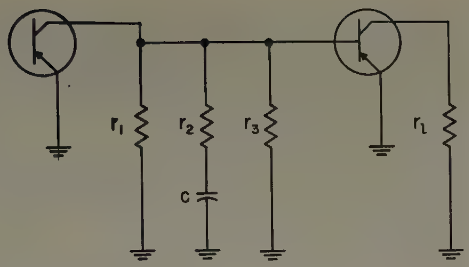


Fig. 11. Basic transistor circuit

of shunt input impedance makes it impossible to get the same curve of frequency compensation, hence the requirement for two compensating networks.

Another feature of this amplifier is the use of an unbypassed resistor in the first emitter circuit. This serves to increase the input impedance of this stage to the required 60,000 ohms, although at the cost of some gain. A gain control is inserted between the first and second stage to adjust the over-all gain to the desired level.

This amplifier has an undistorted output of 2 milliwatts and an over-all gain of approximately 60 db. Signal-to-noise factor was 50 db at 50 cycles. Fig. 13 gives the over-all frequency response.

A final comparison is in order. The tube amplifier employs one dual triode versus three transistors, 8 resistors versus 13, 5 capacitors versus 9. On the favorable side for the transistors are the power requirement, 15 milliwatts total versus approximately 2,000 milliwatts, low voltage requirement, $7^1/_2$ volts versus 150 (plus filament supply), both of which features make the transistor unit suitable for portable battery-operated equipment.

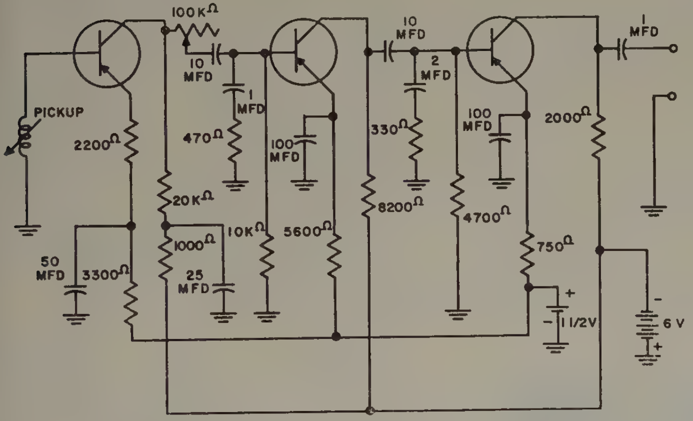


Fig. 12. Circuit of phonograph preamplifier

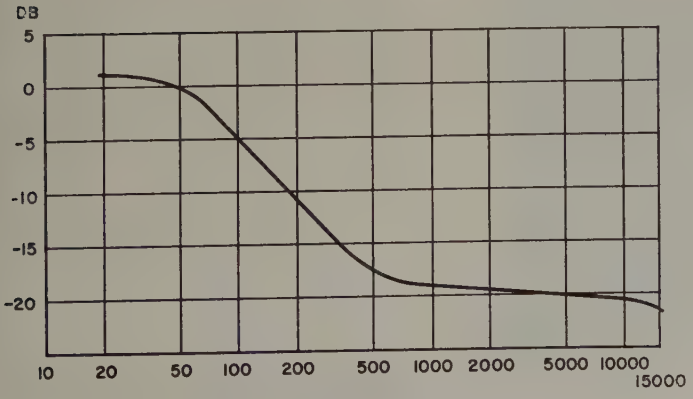


Fig. 13. Frequency response of preamplifier of Fig. 12

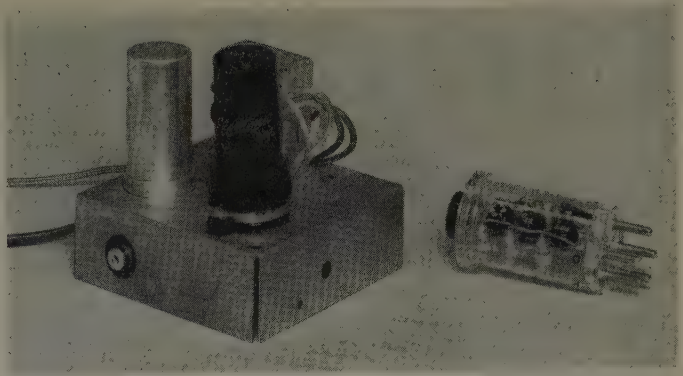


Fig. 14. Conventional preamplifier using the 6SC7 (left) compared with a moderately miniaturized transistor unit version

Fig. 14 shows a conventional preamplifier using the *6SC7* and a moderately miniaturized version of the transistor unit. The comparison is not entirely fair, as the tube unit has a built-in rectifier and works directly from the power line, whereas the transistor unit is designed to obtain its supply through the base connector.

In conclusion it is hoped that the preceding treatment will convince the would-be transistor user that, in spite of the admitted greater complexity of the circuits required by these devices, they will "do nearly everything the tubes will do, and even more." The field of transistor application is extremely wide and there is a real challenge to the enterprising engineer who will take the time to become familiar with them.

Blimp Spots Trouble for Miami

Miami, Fla., a leader in public safety radio, now has extended the use of radio to the air. The Goodyear blimp, *Ranger*, based in the Florida city during the winters, has been equipped with Motorola 2-way vhf radio, enabling its crew to communicate directly with ships at sea, all types of land vehicles, and even portable "Handie-Talkie" units.

If a boat becomes stranded in Biscayne Bay or a child lost in the palmetto thickets, the *Ranger* can serve as a spotter to guide rescuers.

Captain Verner L. Smith of the *Ranger* believes this is the first time such public safety equipment has been installed aboard a civilian blimp. The installation was made by the City of Miami through Ben Demby, communications superintendent.

Two-frequency operation puts the *Ranger* in constant touch with all law enforcement agencies throughout six counties in southern Florida.

The aerial radio is the latest aid to public safety used by Miami, which has pioneered in the use of emergency radio.

Engineering and Research Will Be Theme of 1954 North Eastern District Meeting

The AIEE North Eastern District Meeting for 1954 will be held in Schenectady, N. Y., May 5–7. The Hotel Van Curler will serve as headquarters for the meeting and all technical sessions will be held there.

Included in the program will be papers covering various aspects of power generation, magnetic amplifiers, semiconductors, power system continuity, industrial control applications, and land transportation, as well as rotating machines, computing devices, industrial power systems, transformers, capacitors, and feedback control systems. Of note will be four papers to be presented on the problem of transition in research and engineering. In addition, one day of the meeting, Friday, May 7, will be devoted to special sessions featuring papers covering developments in the fields of nucleonics and textiles.

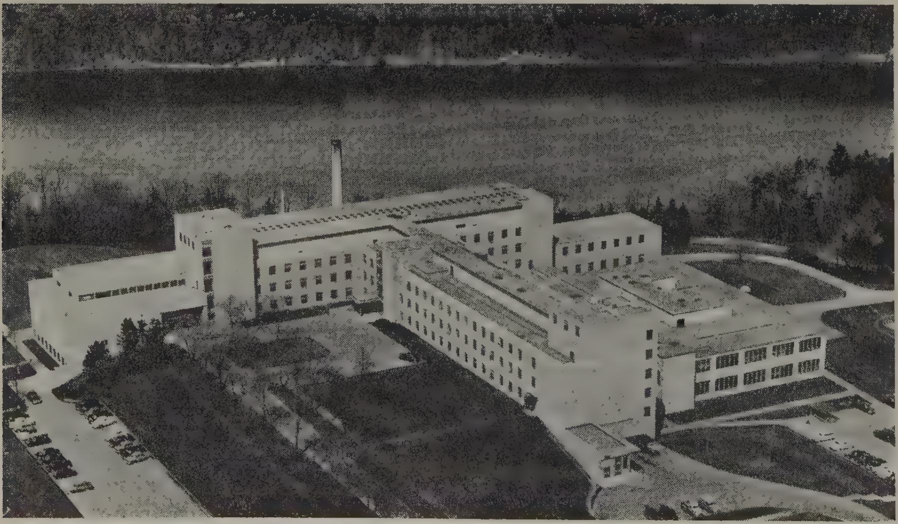
INSPECTION TRIPS

General Electric Company Turbine Manufacturing Building (Thursday, May 6, 1:30–4 p.m.; Friday, May 7, 9:30–12 a.m.; Student Session, Friday, May 7, 1:30–4 p.m.). The turbine building, covering 21 acres, is one of the largest machine shops in the world and provides work for 6,800 employees. Visitors will be able to see the manufacturing, assembly, and testing operations involving approximately 1,500 machine tools of various kinds required for the production of large steam turbines and generators for central station use. Currently being assembled is a 125,000-kw set to operate with 4,500 pounds per square inch steam at 1,150 F.

Niagara Mohawk Albany Steam Station (Friday, May 7, 9:30–12 a.m.). This is the newest generating station on the Niagara Mohawk system and when completed will consist of four identical units, each rated 80,000 kw, using 1,450 pounds per square inch steam at 1,000 F. The first two units are now in operation and the last two units will be completed late this summer. These units are operated on pulverized coal with a unit scheme of generation. This is an opportunity to see one of the most up-to-date plants in the country.

The American Locomotive Company (Thursday, May 6, 9:30–12 a.m.). The Schenectady plant began operation in 1884 and was, for many years, the nation's leading builder of steam locomotives. In 1924 the American Locomotive Company built the first commercially successful diesel-electric locomotive. Since that time the company's diesel-electric locomotive production has increased and since 1948 it has been entirely this type. Visitors will be able to see the diesel-engine manufacturing and assembly facilities as well as the locomotive assembly area. The American Locomotive Company presently serves many industries including transportation, petrochemical, power, mechanical equipment, and oil production with diversified products. They are now in the process of manufacturing the main shield for use in the construction of the third Lincoln tunnel.

Atomic Energy Commission Installations (Thursday, May 6, 1:30–4 p.m.). Although the details of this trip are not complete at present, it is planned that visitors will see Atomic Energy Commission installations at the Knolls and at West Milton. These plants are devoted to development work on atomic-energy-driven submarine and other problems. Proof of United States citizenship is required in order to visit these installations.



Aerial view of the General Electric Research Laboratory which will be the site of a North Eastern District Meeting inspection trip

All inspection trips will leave the Hotel Van Curler by bus. Tickets may be purchased in advance or at the time of registration. These tickets will be 50¢ each with the exception of the trip to the Niagara-Mohawk Albany Steam Station which will be 75¢.

SOCIAL ACTIVITIES

On Wednesday evening, May 5, at 6 p.m., there will be a smoker for all members. There will be a social hour starting at 6 o'clock, followed by dinner at 7 with a planned program beginning at 8:15. Dr. Murray Banks, whose reputation as a humorist equals his reputation as a psychologist, will be the featured speaker. Tickets will be available in advance and at the registration desk. Price of the tickets will be $5.50 and transportation will be available from the Hotel Van Curler to the Edison Club.

On Thursday evening, May 6, a buffet supper will be held at Union College. Bus transportation will be available from the Hotel Van Curler at 6 o'clock with the dinner scheduled to start at 6:15. Dr. Carter Davidson, president of Union College, will act as master of ceremonies, and President Elgin B. Robertson will be the featured speaker. It is planned that the dinner will be completed by 8:30 so that those who wish may attend the Steinmetz Lecture. Tickets for this event will be available in advance or at the registration desk at a cost of $3.00.

The Steinmetz Lecture will be held on Thursday evening, May 6, at 8:30 p.m., in the Union Memorial Chapel. This 26th annual Steinmetz Lecture will be given by Charles Allen Thomas, president of Monsanto Chemical Company. The talk will emphasize the theme of the meeting, "Engineering and Research—Pillars of Progress." The title of Mr. Thomas' lecture has not been announced. This lecture is free and open to the public.

In consideration of the outstanding technical and scientific ability possessed by Dr. Steinmetz, and of his broad human interests and varied activities, the Steinmetz Memorial Foundation was established in 1925. By subscription among his many friends and admirers, a fund was collected and placed in permanent trust under the administration of the AIEE Schenectady Section. The Foundation provides for public lectures by eminent scientists and engineers, in honor of Charles Proteus Steinmetz, whose personality and achievements thus will be recalled periodically by the delivery and publication of the Steinmetz lectures.

There will be a Textile Subcommittee luncheon at noon Friday, May 7, at the Van Curler Hotel. All those attending the textile sessions are invited. Tickets will be available at the registration desk.

LADIES' PROGRAM

The ladies' headquarters will be in the Social Room at the Hotel Van Curler. Coffee will be served each morning. Hostesses will be on hand at all times to extend

Production floor at General Electric's turbine and generator facilities, to be inspected during the North Eastern District Meeting

a welcome, help the ladies get acquainted, and answer any questions.

Through the generosity of Mrs. William C. White, the general chairman of the Ladies' Committee, the ladies will enjoy a tea in her home on Wednesday afternoon, May 5. A dinner and card party will be held in the evening at the Mohawk Golf Club.

The vicinity of Schenectady is noted for its many places of historic interest. On Thursday morning, May 6, a bus trip is planned which will take the ladies through Schenectady's old sections, then to Albany, the capitol, the Schuyler Mansion, on to Saratoga site of the famous race track and health resort, and to Skidmore College. There will be a luncheon at the Gideon-

(*Continued on page 368*)

Tentative Technical Program

North Eastern District Meeting, May 5-7

Wednesday, May 5

9:00 a.m. Power Generation

DP.* Albany Steam Plant. *J. M. Geiger*, Niagara Mohawk Power Corporation

DP.* An Automatic Hydroelectric Development. *W. C. VanDyke*, Niagara Mohawk Power Corporation

DP.* Motor-Driven Exciter Sets for Power Stations. *M. Temoshok, J. B. Tice*, General Electric Company

DP.* Steam Turbine Generators of the Future. *R. S. Neblett*, General Electric Company

9:00 a.m. Magnetic Amplifiers

DP.* Amplistats With Inductive D-C Loads. *H. F. Storm*, General Electric Company

DP.* Magnetic Amplifier Applications. *R. W. Moore*, Westinghouse Electric Corporation

54-198. Pulse Relaxation Amplifier—A Low-Level D-C Magnetic Amplifier. *R. E. Morgan, J. B. McFerran*, General Electric Company

DP.* The Cyclic Integrator—a Device for Measuring the Frequency Response of Magnetic Amplifiers. *T. Dunnegan*, Chance Vought Aircraft, Inc.; *J. D. Hardnen, Jr.*, General Electric Company

9:00 a.m. Semiconductors

DP.* Germanium Diodes and Transistors. *J. M. Early*, Bell Telephone Laboratories

DP.* Electroluminescence. *J. F. Waymouth*, Sylvania Electric Products, Inc.

DP.* Photosensitive Materials and Devices. *R. G. Seed*, Transistor Products, Inc.

DP.* The Ferrites. *V. C. Wilson*, General Electric Company

2:00 p.m. Power Systems and Service Continuity

DP.* The Problem. *G. D. Floyd*, Hydro-Electric Power Commission of Ontario; *C. B. Kelly*, Interchange Power Services Inc.

DP.* The Power System as a Whole. *M. H. Mackenzie*, Hydro-Electric Power Commission of Ontario

54-186. Power and Energy Production. *C. W. Watchorn*, Pennsylvania Water and Power Company

DP.* The Power Distribution System. *G. G. Auer*, General Electric Company

DP.* System Transmission and Transformation. *O. A. Starcke*, Kansas City Power and Light Company

54-188. Industry Co-ordination of Microwave Communication Systems. *V. J. Nexon*, Microwave Services, Inc. Re-presented for discussion

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* **DP:** District paper; no advance copies are available; not intended for publication in *Transactions*.

Future AIEE Meetings

Conference on Rubber and Plastics
Mayflower Hotel, Akron, Ohio
April 5–6, 1954
(*Final date for submitting papers—closed*)

Southern Textile Conference
A. French Textile School of Georgia Institute of Technology, Atlanta, Ga.
April 15–16, 1954
(*Final date for submitting papers—closed*)

Conference on Feedback Control Systems
Claridge Hotel, Atlantic City, N. J.
April 21–23, 1954
(*Final date for submitting papers—closed*)

Military Communications Conference
Western Union Auditorium, New York, N.Y.
April 28, 1954
(*Final date for submitting papers—closed*)

AIEE-IRE-RETMA-WCEMA Electronic Components Conference
Roger Smith Hotel, Washington, D. C.
May 4–6, 1954
(*Final date for submitting papers—closed*)

North Eastern District Meeting
Van Curler Hotel, Schenectady, N. Y.
May 5–7, 1954
(*Final date for submitting papers—closed*)

Appliance Technical Conference
Morrison Hotel, Chicago, Ill.
May 17–19, 1954
(*Final date for submitting papers—closed*)

Electric Welding Conference
Schroeder Hotel, Milwaukee, Wis.
May 19–21, 1954
(*Final date for submitting papers—closed*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 24–26, 1954
(*Final date for submitting papers—closed*)

Summer and Pacific General Meeting
Biltmore Hotel, Los Angeles, Calif.
June 21–25, 1954
(*Final date for submitting papers—closed*)

Petroleum Technical Conference
Tulsa, Okla.
September 27–29, 1954
(*Final date for submitting papers—June 28*)

Middle Eastern District Meeting
Abraham Lincoln Hotel, Reading, Pa.
October 5–7, 1954
(*Final date for submitting papers—July 7*)

Fall General Meeting
Morrison Hotel, Chicago, Ill.
October 11–15, 1954
(*Final date for submitting papers—June 14*)

Machine Tool Conference
Hotel Stutler, Detroit, Mich.
October 25–27, 1954
(*Final date for submitting papers—June 25*)

Southern Textile Conference
Raleigh, N. C.
November 4–5, 1954
(*Final date for submitting papers—August 4*)

1955 Winter General Meeting
Hotel Statler, New York, N. Y.
January 31–February 4, 1955
(*Final date for submitting papers—October 20*)

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

2:00 p.m. Control and Industrial Applications

DP.* Automatic Log-Handling Cranes. *C. B. Risler*, Westinghouse Electric Corporation

DP.* Automation in Heavy Material-Handling Equipment. *E. H. Abbe*, General Electric Company

DP.* Controlled Tension by Eddy Current. *R. H. Garrett, R. R. Dirksen*, Dynamatic Corporation

DP.* D-C Systems for Tension Control. *W. W. Litfin*, General Electric Company

2:00 p.m. Land Transportation

54-189. A World-Wide Standard Traction Motor for Diesel-Electric Locomotives. *M. J. Baldwin*, General Electric Company

DP.* The New ALCO 2,250-Hp Road Switching Locomotive. *N. J. Hochanadel, C. F. Schwenker*, American Locomotive Company

DP.* Horsepower Tractive Effort and Adhesion of Diesel-Electric Locomotives. *D. W. McLaughlin*, General Electric Company; *M. C. Swanson*, American Locomotive Company

DP.* Ignitron Multiple Unit Cars. *W. L. Barclay, Jr.*, Westinghouse Electric Corporation

DP.* A New Engine Temperature Control for Diesel-Electric Locomotives. *E. F. Weiser*, General Electric Company

54-190. Static Excitation Control for Diesel-Electric Locomotives. *S. W. McElhenny, R. M. Smith*, General Electric Company. Re-presented for discussion

Thursday, May 6

9:00 a.m. Rotating Machines

DP.* Field Preheating for Large Turbine Generators. *W. J. Gilson*, General Electric Company

DP.* Vibration in 2-Pole Induction Motors Related to Slip Frequency. *E. V. Summers*, Westinghouse Electric Corporation

54-191. Harmonics Due to Slots in Electric Machines. *R. A. Heartz*, Minneapolis Honeywell Company; *R. M. Saunders*, University of California

54-192. The Direct Calculation of Maximum Amplitude in Transient Responses. *D. G. Lewis*, General Electric Company

DP.* Analysis of Short-Circuit Oscillograms. *S. L. Mikhail*, Ibrahim University

9:00 a.m. Computers in Engineering Analysis

DP.* Use of Computers in Application Engineering. *R. Habermann, Jr., D. F. Langenwalter*, General Electric Company

DP.* Digital Computer Solution of Scheduled Air Traffic. *F. M. Verzuh*, Massachusetts Institute of Technology

DP.* Problems Associated With Converting to a Univac System. *R. F. Osborn*, General Electric Company

DP.* Examples of Engineering Applications on IBM Digital Computers. *I. C. Liggett*, International Business Machines Corporation

9:00 a.m. Industrial Power Systems

DP.* Relay Response to Motor Residual Voltage During Automatic Transfers. *A. R. Kelly*, Standard Oil Development Company

DP.* An Expanded and Modernized Industrial Power System. *G. E. Baker, C. E. Weaver*, Eastman Kodak Company

DP.* 480/277-Volt Lighting System in Telephone Building at Menands. *H. D. Donnelly*, New York Telephone Company; *D. S. Brereton*, General Electric Company

DP.* Power Distribution System at the Norton Company, Worcester, Mass. *P. L. Russell*, General Electric Company

2:00 p.m. Transformers and Capacitors

54-193. A Method of Estimating Lighting Performance of Distribution Lines. *J. M. Clayton, A. R. Hileman*, Westinghouse Electric Corporation

54-194. Traveling-Wave Protection Problems. *E. W. Boehne*, Massachusetts Institute of Technology

DP.* Thyrite Protection for Series Windings of Autotransformers. *J. W. Albright*, General Electric Company

54-195. Voltage Unbalance in Delta Secondaries Serving Single-Phase and 3-Phase Loads. *A. S. Anderson*, Ebasco Services, Inc.; *R. C. Ruete*, General Electric Company

DP.* Factors Determining the Economic Size of Capacitors. *A. E. Peltasalo, R. J. Hopkins*, General Electric Company

2:00 p.m. Research and Engineering—the Problem of Transition

DP.* The University Laboratory. *A. F. Sise*, Massachusetts Institute of Technology

DP.* The Independent Research Laboratory. *Allan Latham, Jr.*, Arthur D. Little, Inc.

DP.* The Government Laboratory. *D. F. Marlowe*, U. S. Naval Ordnance Laboratory

DP.* The Industrial Laboratory. *V. H. Fraenkel*, General Electric Research Laboratory

2:00 p.m. Feedback Systems

DP.* The Use of Analogue Computers in the Study of Instrument Servos. *R. L. Hovious*, Goodyear Aircraft Corporation

54-196. Transient Analysis of Sampled-Data Control Systems. *G. W. Johnson, D. P. Lindorff*, University of Connecticut

54-197. The Influence of Time Scale and Gain on Criteria for Servomechanism Performance. *D. Graham, R. C. Lathrop*, Wright Air Development Center

DP.* Transient Analysis of A-C Servomechanism. *S. S. L. Chang*, New York University

Friday, May 7

9:00 a.m. Conference on Nucleonics

DP.* Compact Radiation Source. *T. T. Naydan*, General Electric Company

DP.* Thermal Test Reactor. *E. R. Garttner*, General Electric Company

DP.* Synchrotron Experiments. *D. R. Corson*, Cornell University

DP.* High-Energy Electrons in Medicine and Industry. *J. G. Trump*, Massachusetts Institute of Technology

DP.* Handling and Viewing of Radioactive Materials. *P. A. Halpine*, Westinghouse Electric Corp.

9:00 a.m. Conference on Textiles

DP.* Finishing Ranges for Carpets. *L. A. Runton*, Alexander Smith, Inc.

DP.* Electric Heating in Textile Finishing. *John McCreary*, McCreary Machine Works

2:00 p.m. Conference on Nucleonics

DP.* General Observation in Nuclear Energy. *H. A. Bethe*, Cornell University

DP.* Control of Nuclear Reactors. *J. L. Owens, J. Pigott*, General Electric Company

DP.* Low-Speed Rotor Motors for Sealed Systems. *W. E. McCown*, Westinghouse Electric Corporation

DP.* Important Factors in Coolants for Nuclear Reactors. *E. A. Luebke*, General Electric Company

DP.* Road Blocks Besetting Progress in Atomic Power. *J. K. Pickard*, Atomic Energy Commission

2:00 p.m. Conference on Textiles

DP.* Report on NEMA and Textile Subcommittee: Co-operation for Control Enclosures for Textiles. *V. Sepavich*, Crompton and Knowles Loom Works

DP.* Carpet and Felt Loom Drives and Drive Requirements. Panel Discussion: Moderator—J. H. Johnson, Roxbury Carpet Company; R. B. Wood, Albany Felt Company; L. T. Jester, General Electric Company; F. D. Snyder, Westinghouse Electric Corporation

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(*Continued from page 367*)

Putman Hotel, a famous hostelry. The General Electric Research Laboratory will be the scene of the ladies' tour on Friday morning, May 7. Luncheon will be held in their attractive dining room.

HOTEL RESERVATIONS

Rooms have been set aside at the Hotel Van Curler (meeting headquarters) for members and guests. Requests for reservations should be sent prior to April 20 to John Fors, Van Curler Hotel, Schenectady, N. Y., mentioning the AIEE. Mr. Fors will co-ordinate all hotel reservations. In view of the large number of double rooms available, to insure reservations at the headquarters hotel and make maximum use of the available facilities, members and guests are urged to request double accommodations wherever possible. It may be necessary to transfer some reservations to other local hotels.

Accommodations are as follows:

Single room	$ 4.50 and up
Double room	$ 6.00 and up
Sample room	$ 7.00 and up
Suite	$16.00

STUDENT ACTIVITIES

The program for student activities on May 7 will be as follows:

9:30 a.m.—Student paper contests

12 o'clock—Luncheon at the Van Curler Hotel for Student Branch chairmen and counselors

1:30 p.m.—Student trips to General Electric Company Turbine Manufacturing Building and General Electric Research Laboratory

DISTRICT MEETING COMMITTEES

Members of the 1954 AIEE North Eastern District Meeting Committees are

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More Than 600 Participate in Recent Joint Conference on Transistor Circuits

The AIEE–Institute of Radio Engineers (IRE) Conference on Transistor Circuits, held in Philadelphia, Pa., February 18–19, 1954, presented 18 papers to over 600 registrants, including some from Canada and England. Originally scheduled for the University of Pennsylvania Museum Auditorium, the meetings were moved to the university's Irvine Auditorium because of the large attendance.

In his address of welcome, Dr. G. P. Harnwell, president of the University of Pennsylvania and distinguished physicist, called attention to the many close ties between the university and the sponsoring professional societies, and expressed the hope that the AIEE and the IRE would continue to make extensive use of the facilities of the university for their symposia and conferences. He then discussed briefly the state of our knowledge of the physics of materials.

The technical papers presented at the conference covered several aspects of the transistor-circuit art.

The first session, whose chairman was H. E. Tompkins of the Burroughs Research Center, was concerned with the properties and representation of transistors from both the "black-box" and "transparent-box" points of view. In the first paper, J. M. Early, Bell Laboratories, reviewed the basic physical phenomena underlying junction transistor operation. J. Zawels, RCA Victor (whose paper was read by H. Johnson of RCA Laboratories), then presented a new equivalent circuit for junction transistors, in which the passive part corresponds closely to the physics of the device, and the active part is a frequency-independent amplifier. J. B. Angell, Philco Corporation, presented two equivalent circuits for surface-barrier transistors, and indicated the superiority of one in which the space-charge-layer widening effect on emitter current is represented by a resistor connected directly between collector and emitter, rather than by a series element in a *T*-equivalent. J. S. Schaffner, General Electric Company, presented data on the variation of junction transistor parameters with operating point and temperature, and emphasized that in some cases in which a-c parameters are fairly constant with temperature, the d-c bias point is a severe function of temperature; as an example of this he cited the input characteristic of the grounded base (and hence also of the grounded emitter) amplifier stage.

In the second session, conducted by J. G. Linvill of Bell Telephone Laboratories, chairman of the program committee, transistors in linear circuits were discussed. G. C. Sziklai, RCA Laboratories, first discussed several new complementary-symmetry circuits, including a simple 2-stage amplifier whose direction of amplification can be changed by a single-pole double-throw switch. E. R. Kretzmer, Bell Laboratories, presented several examples of the use of other semiconductor devices (such as thermistors and breakdown diodes) as stabilizing elements in transistor circuits. F. P. Keiper, Jr., Philco Corporation, derived his neutralizing circuit, which was described originally in the December 1952 issue of the *Proceedings* of the IRE. S. J. Mason of the Research Laboratory of Electronics at the Massachusetts Institute of Technology, discussed the invariance of the "available power gain" of an active 3-terminal network. P. L. Bargellini, of the Moore School of Electrical Engineering, University of Pennsylvania, a consultant for RCA Victor, presented data indicating that a substantial fraction of present-day junction transistors are more quiet than tubes, and have a low, flat noise spectrum through the audio range, rather than a $1/f$ dependence of noise on frequency. At very low frequencies, the $1/f$ dependence sets in, however.

In the third session, under T. R. Finch of Bell Telephone Laboratories, various junction transistor amplifiers were discussed. C. R. Hurtig, Research Laboratory of Electronics, Massachusetts Institute of Technology, described a transistor d-c amplifier, and noted the limitations on performance caused by the temperature dependence of present units. R. F. Shea, General Electric Company, discussed the choice of configuration and operating point for audio power amplifiers, and demonstrated an 18-watt push-pull class-*B* audio amplifier, using two experimental power transistors in the common-base connection as the output stage. Three Bell Laboratories speakers, F. H. Blecher, R. E. Yaeger, and L. G. Schimpf, presented examples of particular types of amplifier, including summing and integrating amplifiers for analogue computers, carrier-frequency feedback amplifiers, and junction-tetrode i-f amplifiers, respectively.

The final session, on nonlinear applications of junction transistors, had A. W. Lo of RCA Laboratories as its chairman. J. J. Ebers and J. L. Moll of Bell Telephone Laboratories presented a theory of the large-signal d-c and transient behavior of junction transistors. This theory, while closely related to the physics of transistors, is clear and simple enough to be of definite practical utility in circuit design. D. E. Deuitch of RCA Victor discussed some basic switching circuits. J. T. Warnock, Philco Corporation, presented a design method for obtaining reliable switching circuits using any transistors whose parameters fall within a specified range. Mr. Warnock also described a very simple diode clamping circuit for preventing carrier-storage turn-off delay in junction-transistor switching circuits. This last session is, to the

Irving Wolff (left), chairman of the National Committee for the AIEE-IRE Conference on Transistor Circuits, in discussion with, from left to right, H. E. Tompkins, J. G. Brainerd, K. H. Emerson, W. R. Clark, and J. G. Linvill

best of our knowledge, the first meeting at which junction-transistor switching circuits have been discussed in detail.

Many of the papers presented at the conference will be published in journals of the authors' choice, but no "proceedings" of the conference will be issued. This policy was adopted to insure that the conference would include the latest information on the transistor-circuit art; a strict publication policy would have delayed the presentation of some papers until a subsequent meeting. It is evident that the conference was not the "last word" on the subject, since the art is still progressing with great rapidity, and it is expected that similar conferences will be organized in the future, as the need for such meetings arises.

The committees for the conference were

National Committee: (Chairman), I. Wolff; (Secretary), J. S. Donal, Jr.; (Treasurer), M. S. Corrington; (Representing IRE and the PGCT), H. J. Carlin, M. Dishal, J. G. Linvill, L. G. Cumming; (Representing AIEE), W. R. Clark, H. C. Steiner, W. L. LePage, R. S. Gardner; (Representing IRE Philadelphia Section), W. H. Forster; (Representing AIEE Philadelphia Section), W. G. Amey; (Representing functional committees), K. H. Emerson, H. E. Tompkins.

Program Committee: (Chairman), J. G. Linvill; W. C. Dunlap, T. R. Finch, H. L. Flowers, W. H. Forster, A. W. Lo, S. J. Mason, H. L. Owens, J. J. Suran, H. E. Tompkins, F. H. Williams.

Local Arrangements Committee: (Chairman), K. H. Emerson; (Registration), L. H. Good, *Chairman*, J. J. Goodman, N. Koss; (Facilities), P. L. Bargellini, W. Eells, R. Mattis; (Sessions), R. G. Lex, *Chairman*, M. B. Finkelstein, D. W. Hudgins.

Publicity Committee: (Chairman), H. E. Tompkins; F. P. Keiper.

Technical Progress Will Be Evaluated at Electronics Components Symposium

The 1954 Electronics Components Symposium will be held in the Department of Interior Auditorium, Washington, D. C., on May 4–6. The theme this year is "Technical Progress in Component Development, Fabrication, and Use, With Emphasis on New Advances in the Art." The fifth of a series of national meetings on electronic component parts and materials, the symposium is being sponsored jointly by the AIEE, the Institute of Radio Engineers, the Radio-Electronics-Television Manufacturers Association, and the West Coast Electronic Manufacturers Association, with active participation by agencies of the Department of Defense and the National Bureau of Standards. The headquarters hotel will be the Roger Smith.

The program for the technical gathering was arranged by a committee of electronic experts under the chairmanship of A. W. Rogers, who is with Signal Corps Engineering Laboratories, Fort Monmouth, N. J. Emphasizing new advances in the electronic art, the opening session is entitled "The Executive Views Components," and features leading government and industry executives. The people will be welcomed at this session by Donald A. Quarles, Assistant Secretary of Defense (Research and Development). Major General George I. Back, Chief Signal Officer, will speak on "Electronics—A Vital Part of Our Defense."

Registration for the 3-day meeting is \$1.50 if paid in advance and \$2.50 if paid at the door. Published proceedings containing complete transcripts of all papers are expected to be available about 3 months after the conference: The price is \$3.50 if advance payment is made; the post-symposium price will be \$4.50. Advance registrations, orders for the proceedings, and all remittances should be sent to A. E. Zdobysz, Treasurer, 1954 Electronic Components Symposium, 1 Thomas Circle, Washington, D. C.

Tuesday, May 4

10:00 a.m. Welcome

The Honorable Donald A. Quarles, Assistant Secretary of Defense (Research and Development)

Session 1. The Executive Views Components

Chairman: A. W. Rogers, Signal Corps Engineering Laboratories

Introductory Remarks: M. Barry Carlton, Office of the Assistant Secretary of Defense (Research and Development); Chairman, Symposium Steering Committee

Electronics—A Vital Part of Our Defense. *Major General G. I. Back*, Chief Signal Officer

The Components Engineer—His Place and Importance. *R. C. Sprague*, Sprague Electric Company

Component Engineering as a Part of System Design. *C. H. Elmendorf*, Bell Telephone Laboratories, Inc.

Survey of European Component Development. *R. S. H. Hylkema*, Philips Industries

Emphasize the Negative. *D. E. Noble*, Motorola, Inc.

2:00 p.m. Session 2. Relationship of Materials Developments to Component Progress

Chairman: J. T. Brothers, Philco Corporation

Synthetic Resins as Coatings and Castings. *J. C. Souter*, Western Electric Company

An Evaluation of the Effect of MFP Treatments on Parts and Materials. *C. P. Lascaro*, Signal Corps Engineering Laboratories

Metal Whiskers. *S. M. Arnold*, Bell Telephone Laboratories, Inc.

Dielectric and Coolant Studies of Inert Fluorochemical Liquids. *M. Olyphant, Jr.*, *T. J. Brice*, Minnesota Mining and Manufacturing Company

Corona Measurement as a Criterion of Insulation Life. *J. F. McNaughton*, Inland Testing Laboratories, Division of Cook Electric Company

The Growth of $BaTiO_3$ Single Crystals for Use as Storage Elements. *J. P. Remeika*, Bell Telephone Laboratories, Inc.

Stabilized High-Permittivity Barium Titantate. *H. I. Oshry*, Erie Resistor Corporation. Presented by title

Wednesday, May 5

9:00 a.m. Session 3. Solid-State Devices and Companion Components

Chairman: R. F. Shea, General Electric Company

p-n-p Alloy Junction Photo Transistor. *H. Sandler*, Radio Receptor Company, Inc.

Double-Base Diodes as Components. *J. J. Suran*, General Electric Company

High-Temperature Selenium Rectifiers. *M. Schneider*, Radio Receptor Company, Inc.

The Electrical Properties of Titanium Dioxide Rectifiers. *T. S. Shilliday*, *C. S. Peet*, Battelle Memorial Institute

Reliability of Quantity-Produced Transistors in Low-Power Audio Applications. *F. M. Dukat*, Raytheon Manufacturing Company

Special Battery Supplies for Transistor Applications. *J. Dalfonso*, P. R. Mallory and Company, Inc.

2:00 p.m. Session 4. New Frontiers in Component Development

Chairman: Jesse Marsten, International Resistance Company

Evaporated Metal Film Resistors. *S. J. Stein*, *J. Riseman*, International Resistance Company

General Design and Performance Characteristics of Film-Type Potentiometers. *L. Krauss*, Fairchild Camera and Instrument Corporation

Recent Trends in Terminals for Hermetically Sealed Components. *E. D. Tidd*, Bell Telephone Laboratories, Inc.

Capacity Variations With Temperature for the Sintered-Plate Nickel-Cadmium Battery. *D. L. Lawson*, Sandia Corporation

R-F Circuit Elements With Accurately Adjustable Losses. *J. A. Connor*, Radio Corporation of America

Mellon Optical Storage System. *A. Milch*, Mellon Institute of Industrial Research, University of Pittsburgh

8:00 p.m. Session 5. New Frontiers in Component Development (Continued)

Chairman: P. S. Darnell, Bell Telephone Laboratories, Inc.

Propagation of Electromagnetic Waves in Ferrites. *A. D. Perry*, Bell Telephone Laboratories, Inc.

Improved Components Based on Ferrite Materials. *N. Cushman*, *M. Geroulo*, *D. Peck*, Sprague Electric Company

Factors Affecting Transformer Life, the Criteria of Transformer Failure, and a Suggested Test Cycle. *G. E. Walter*, *R. L. Hamilton*, General Electric Company

Electromagnetic Delay Lines. *H. G. Nordlin*, Federal Telecommunication Laboratories, Inc.

Broadband Waveguides for a 4-to-1 Frequency Coverage. *S. Hopfer*, Polytechnic Research and Development Company

Components for a 2,000-Mc Oscillator and Amplifier Circuits. *N. E. Colby*, Radio Corporation of America

Thursday, May 6

9:00 a.m. Session 6. Component Requirements for Computers, Guided Missiles, and Other New Applications

Chairman: F. A. Paul, Northrop Aircraft, Inc.

Component Parts Requirements and Evaluation for Large-Scale Computer Applications. *R. D. Slonaker*, *B. L. Stone*, International Business Machines Corporation

What Guided Missiles Do to Components. *H. A. Stine*, Capehart-Farnsworth Company

Misapplication of Relays in Complex Air-Borne Electronic Equipment. *M. R. Sumner*, Northrop Aircraft, Inc.

Potentialities of Bimags in Circuits of Information-Processing Systems. *I. L. Auerbach*, Burroughs Corporation

D-C to Kilomegacycles Wide-Band Amplifiers. *H. Stockman*, Scientific Specialities Corporation

A Note on the Use of Components in R-F Interference Suppression. *S. J. Burruano*, Radio Corporation of America

2:00 p.m. Session 7. Automation—Its Impact on Components

Chairman: W. G. Tuller, Melpar, Inc.

An Approach to the Automatic Production of Electronic Equipment. *L. K. Lee*, Stanford Research Institute

Achievement of Reliability by the Use of Functional Subassemblies as Standard Building Blocks. *J. W. Brush*, Bureau of Ships, Department of the Navy

"Project Mini-Mech" (Miniaturized and Mechanized Assembly of Electronic Units). *A. A. Lawson*, Melpar, Inc.

The Development of an Automatic Component Assembly System. *W. Hausz, I. Katz*, General Electric Company

Reliable Receiving Tubes Designed for Automatic Production. *W. R. Wheeler*, Sylvania Electric Products, Inc.

Los Angeles Section Holds February Meeting With IES

More than 180 members and guests of the Los Angeles Sections of the AIEE and the Illuminating Engineering Society met jointly in February to hear H. A. Wolbers, Jr., of Psychological Services, Inc., discuss the relations between sight and illumination. Also present at the dinner-meeting was AIEE President Elgin B. Robertson who, when introduced by Chairman C. A. Wells, commented on AIEE activities in general.

As the main speaker of the evening, Mr. Wolbers used slides and attention-holding demonstrations to illustrate the effects of light and how the human mechanism registers and reacts to these effects. Engineers are too prone to consider that vision is only a matter of adequate light source, he said, but this is not true since seeing starts with the human mechanism, which is a very complex system involving not only the eyes but the entire organism.

Mr. Wolbers utilized a progressive series of verbal and visual illustrations showing the mechanics of sight, and demonstrated the effects of how visual retention makes things seem not what they are.

CIGRE Issues Report on Survey of Corona Losses

A survey of the results of measurements on high-voltage overhead line conductors is the subject of a report on "Corona Losses" recently issued by the International Conference on Large Electric High-Voltage Systems (CIGRE) and available as AIEE Special Publication *S-60* from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. The price is 75¢ per copy.

Based on a study of the corona effect in extra-high-voltage testing stations in Sweden, Switzerland, France, Great Britain, and the United States, three types of losses are examined: in fair weather, during precipitations, and total losses on a long line. In conclusion, the main results made available by the studies of the corona effect known up to date are summarized, and those which should be precised usefully by new tests are pointed out.

The report, which was prepared by François Cahen and René Pelissier, has been issued as an 88-page illustrated, mimeographed booklet.

NBS Director Astin Discusses Research at Washington Section's Student Night

Dr. Allen V. Astin, director of the National Bureau of Standards, was the main speaker at the AIEE Washington (D. C.) Section's Annual Student Night on February 13, 1954, which was attended by some 140 persons. This event is held for the entertainment of Student members from the four colleges in the Section: Catholic University, George Washington University, University of Maryland, and Howard University.

Following dinner and the official welcome from George Washington University, the host school, the Washington Section presented its annual award to the Student member of each local Student Branch doing the most to promote Student Branch activities. The awards, a year's membership as Associate Member of the Institute, this year went to the following students: Paul Emmons, Catholic University; Paul M. Douglass, Jr., George Washington University; James R. Duncan, Howard University; and Thomas R. Evans, University of Maryland.

In his address as keynote speaker, Dr. Astin discussed "Some Research Trends in Electrical Engineering." Opening his talk with a reference to the fact that Abraham Lincoln had been instrumental in starting the National Academy of Sciences and through his friendship with Louis Agassi had laid the groundwork for a Bureau of Standards, he went on to point out that in 1850 80 per cent of the power was provided by animals, 15 per cent by man, and 5 per cent by machinery, whereas today the ratios are about 84 per cent by machinery, 4 per cent by man, and 12 per cent by animal effort. Closely related to this change is the fact that in 1890 there was one engineer in industry for every 300 workers while in 1950 there was one engineer for every 60 workers in industry. There is, of course, a great shortage of engineers at the present time.

Dr. Allen V. Astin

In his discussion of research trends, Dr. Astin indicated the increased interest in research efforts due to the Defense program but, as he pointed out, many important by-products of military research have found their way into civilian service. Other important trends in electrical engineering include the increasing complexity of devices and machines, the development of automatic control and computing and information processing machines, the practical development of power from atomic energy, research in solid-state physics, and the growth of instrumentation.

In closing, Dr. Astin said that although the engineer normally is thought of as dealing in applications, this need not be strictly the case. He feels that basic research should be carried on for the purpose of increasing knowledge, without regard to its practical application; that there is an element of freedom attached to the capacity to do things just for the sake of gaining knowledge that should not be denied the scientific worker. This fact should be applied even during the pressure of our present era.

Kansas Student Receives Coleman Award

Daniel F. Swarts (center), a senior student in electrical engineering at the University of Kansas and a member of the Joint AIEE–Institute of Radio Engineers Student Branch, receives from W. C. Coleman a $300 check as a winner of the Coleman Company's senior engineering scholarship award. At left is Floyd Quinlisk, Coleman personnel director

Complete Program Announced for Feedback Control Conference

"Applications of Feedback Control" will be the theme of the Second Conference on Feedback Control Systems to be sponsored by the AIEE. The Claridge Hotel, in Atlantic City, N. J., will be the scene of the conference, which will take place April 21–23, 1954.

The conference will feature technical papers on the practical application of feedback techniques in aircraft, computers, industrial regulators, contour machine tools, processing, nucleonics, magnetic amplifiers, and test equipment. A unique and attractive feature will be a series of demonstrations of actual equipment used in the aforementioned fields. These demonstrations are scheduled to be presented to small audiences during special periods devoted to that purpose.

The social highlight of the gathering will be the dinner on Thursday evening, April 22, at which Dr. S. W. Herwald, Westinghouse Electric Corporation, will preside, and Dr. L. N. Ridenour, International Telemeter Corporation, will be the principal speaker.

Registration fee for the conference is $3.00, which will cover a program booklet containing abstracts of all the technical papers and descriptions of all the demonstrations. Tickets for the social hour and banquet will cost $7.50. The conference proceedings, containing complete texts of the technical papers and descriptions of the demonstrations, will be published after the conference, at a price of $3.50.

Further information, and hotel and banquet reservation cards may be obtained by writing to G. L. Stancliff, Jr., Vickers, Inc., 723 15th Street N.W., Washington 5, D. C.

The complete program of the conference, including technical papers and scheduled demonstrations, is as follows:

Wednesday, April 21

10:00 a.m. Registration

2:00 p.m. Technical Session I

Presiding: A. G. Kegel, Westinghouse Electric Corporation

Opening Address: F. E. Crever, General Electric Company (Chairman, AIEE Committee on Feedback Control Systems)

Harmonics in the Reference Voltage of A-C Analogue Computers and Their Effects Upon Servo Response. *I. H. Lohman*, International Business Machines Corporation

Application of Feedback Control System Analytical Methods by the Industrial Regulator Designer. *W. F. Eagan*, Allis-Chalmers Manufacturing Company

Feedback in Contouring Control Systems. *F. J. Ellert*, General Electric Company

Dynamic Study of a Heat Exchanger. *C. W. Worley*, Minneapolis-Honeywell Regulator Company

Thursday, April 22

9:30 a.m. Technical Session II

Presiding: L. C. Harriott, General Electric Company

Gear Considerations. *W. R. Ahrendt*, Ahrendt Instrument Company

High-Performance Plotting Table Servomechanisms for 400-Cps Suppressed Carrier Input. *C. M. Edwards*, Bendix Aviation Corporation; *A. M. Fuchs*, Westinghouse Electric Corporation

Optimization of Linear Closed Loop Systems With Applications to Turbojet Engine Controls. *A. S. Boksenbom, D. Novik, H. Heppler*, National Advisory Committee for Aeronautics

Frequency-Response Methods in Design of Turbojet Engine Controls. *W. M. Gaines*, General Electric Company

A Noise Adaptive Flight Path Control System. *R. J. Keeler, D. L. Markusen*, Minneapolis-Honeywell Regulator Company

2:00 p.m. Scheduled Demonstrations I

6:15 p.m. Social Hour and Dinner

Presiding: S. W. Herwald, Westinghouse Electric Corporation

Speaker: L. N. Ridenour, International Telemeter Corporation

Friday, April 23

9:30 a.m. Technical Session III

Presiding: H. T. Marcy, International Business Machines Corporation

Operational Magnetic Amplifiers for Servomechanism Application. *W. F. Horton, R. O. Decker*, Westinghouse Electric Corporation

The Application of Feedback to the Control of Nuclear Reactors. *F. E. Crever*, General Electric Company

The Language of Feedback Controls. *H. W. Cory*, Allis-Chalmers Manufacturing Company

Serendipity—or How We Learned About Feedback. *G. S. Brown*, Massachusetts Institute of Technology

2:00 p.m. Scheduled Demonstrations II

Scheduled Demonstrations

Fire Control Instrument and Test Equipment. Ahrendt Instrument Company, College Park, Md.

Analogue Computer. Boeing Airplane Company, Seattle, Wash.

Characteristics and Applications of Deposited Film Potentiometers. Fairchild Camera and Instrument Company, Potentiometer Division, Hicksville, N. Y.

Automatically Controlled Nuclear Reactor Simulator. Ferranti Electric Ltd., Toronto, Ont., Canada

Photoelectric Side Register Control. General Electric Company, Schenectady, N. Y.

Principles of Automatic Control (Motion Picture). Instrument Society of America, Pittsburgh, Pa.

Flight Simulator Servo. Link Aviation Inc., Binghamton, N. Y.

Magnetic Control Amplifiers. Naval Ordnance Laboratory, Silver Springs, Md.

Servo Evaluation Equipment. Naval Research Laboratory, Washington, D. C.

Single-Motion Duplicator for Automatic Control of Machine Tools. Raytheon Manufacturing Company, Research Division, Waltham, Mass.

Feedback Control Systems Analyzers. Servo Corporation of America, New Hyde Park, N. Y.

Mechanical Oscillation Dampers for Feedback Systems. Servo Mechanisms, Inc., Components Division, Westbury, N. Y.

Duplicating Attachment for Machine Tools. Turchan Follower Machine Company, Detroit, Mich.

Rate Stabilized Platform. Westinghouse Electric Corporation, Air Arm Division, Baltimore, Md.

Fairman, Hausmann Honored by Professional Engineers

Dr. James F. Fairman (F '35), vice-president of the Consolidated Edison Company of New York, Inc., and a past president of the Institute, and Dr. Erich Hausmann (F '18), dean emeritus of Brooklyn Polytechnic Institute, were honored by their fellow professional engineers at a testimonial dinner in Brooklyn, N. Y., on March 24, 1954.

The dinner was tendered by the Kings County Chapter of the New York State Society of Professional Engineers, of which Dr. Fairman and Dr. Hausmann have been members of long standing, on the occasion of the chapter's Silver Anniversary celebration. A Certificate of Honor award was presented to Dr. Fairman in honor of his appointment to the New York State Board of Examiners of Professional Engineers and Land Surveyors, and to Dr. Hausmann for his outstanding service and contribution to the engineering profession as a past member of the Board of Examiners.

The Honorary Committee for the occasion was headed by Mayor Robert F. Wagner of the City of New York.

ECPD Professional Development Program Discussed in Cincinnati

Local sections of the AIEE, the American Institute of Chemical Engineers, The American Society of Mechanical Engineers, and the American Society of Civil Engineers joined with the Engineering Society of Cincinnati on February 4, 1954, to discuss the "First Five Years of Professional Development," a program for young graduate engineers sponsored by the Engineers' Council for Professional Development (ECPD) Training Committee.

Keynote speaker at the meeting was S. D. Kirkpatrick, past president of the American Institute of Chemical Engineers and vice-president and editorial director of the McGraw-Hill Book Company. Mr. Kirkpatrick, who has an outstanding record of leadership in the field of professional development for young men, spoke on the theme, "At the Threshold of an Engineering Career."

Following the keynote address, the audience was divided into eight discussion groups for round-table sessions relating to the six points of the ECPD program. Subject discussed included:

1. Orientation and Training in Industry.
2. Continued Education.
3. Integration Into the Community.
4. Professional Registration.
5. Self-Appraisal.
6. Selected Reading.

Each of the sections of the four national societies participating and the Engineering Society of Cincinnati designated eight key members to assist in leading these group discussions.

At a preliminary dinner meeting, the 40 members of the eight group panels heard an introductory talk by H. M. Hopkins, vice-president in charge of operations of the Tool Steel Gear and Pinion Company, on "What Makes a Group Tick." These representatives who served in leading the eight different discussion groups represented 32 industries and engineering companies in the Cincinnati area.

This meeting was another in the steps of the ECPD pilot study known as the "Community Project in Professional Development" which is emphasizing the importance of related activities of industry, the engineering societies, and the universities in a typical industrial area.

The project is based on two cardinal principles:

1. Industry and the engineering profession must provide the young engineer with a favorable climate in which to grow.
2. The young engineer must realize that the final responsibility for professional advancement rests with him, the individual.

A report on this pilot study will be given at the annual meeting of the ECPD in October 1954, and plans are now underway to establish similar projects in selected industrial areas throughout the United States and Canada.

Further Plans Announced for Summer and Pacific Meeting

According to the general chairman, Bradley Cozzens, arrangements for the 1954 Summer and Pacific General Meeting at the Biltmore Hotel, Los Angeles, Calif., June 21-25, continue to take shape. As active work by the committees progresses on the program of events it becomes apparent that the schedule of trip and entertainment activities adequately will supplement the technical sessions. At this time it is not possible to give a detailed report on the technical papers, but all indications are that there will be 48 technical sessions, covering a wide variety of fields and of interest to all groups of engineers.

For those whose interest lies in the communications field, The Pacific Telephone and Telegraph Company is making facilities available for inspection trips to important communication centers. Visitors will see the roof of the company's Los Angeles Grand Toll Office where horn lens antennas of the Los Angeles–San Francisco microwave relay system carry television and toll message circuits.

A preview of social activities planned indicates a Sunday afternoon informal tea in the pleasant atmosphere of the Biltmore Hotel Galeria. For Monday evening plans for attending a live television show are being formulated, and on Tuesday evening the planned trip to mile-high Mount Wilson with its world-famous Observatory and its concentration of seven very-high- and two ultrahigh-frequency television transmitters will be of major interest.

Wednesday evening the years will be turned back to the "Gold Rush Days" with the dinner at Knott's Berry Farm restaurant near Buena Park. The authentic atmosphere of the "Ghost Town" with its exhibits both humorous and realistic, will revive the spirit of the Old West for the evening. The President's Reception and Banquet is to be held at the Biltmore Hotel on Thursday evening and will be the climax of the social activities for the Summer and Pacific Meeting.

The Sports Committee is reminding the golfers that the John B. Fisken Cup for Pacific Coast members and the Mershon Golf Trophy for all members will be up for competition.

Under the chairmanship of Mrs. Ernest K. Sadler, a variety of entertainment has been planned for the visiting ladies. In addition to a social tea Sunday afternoon for those who arrive early, an informal tea and fashion show will be held on Monday, June 21, at Bullock's Wilshire in one of the Wilshire Boulevard exclusive shopping districts. Tuesday will include a trip to the Padua Hills Art Colony in the foothills 35 miles east of Los Angeles where native dances of Old Spain and Early California will be enjoyed in conjunction with luncheon, and an opportunity will be provided for the ladies to visit the shops and art displays at the Colony.

Several short trips are planned for Wednesday, including viewing of the famed painting of the Crucifixion by Jan Styka in nearby Glendale; a visit to the Huntington Libraries in San Marino, or other points of interest as arranged to suit the guests. The late afternoon and evening will be devoted to a trip to Knott's Berry Farm as previously mentioned.

A Thursday morning tour of Beverly Hills, the movie colony, and the near-by beaches, will culminate with luncheon at the Wilshire Country Club. This event will not interfere with the President's Reception and Banquet in the evening. A coffee hour will be provided each morning, through Thursday. No trips are arranged for Friday, but the committee will be pleased to assist in satisfying the desires of the visiting ladies.

The Transportation Committee is answering requests for information concerning points of interest which may be seen enroute to and from the meeting in order that members and families may obtain maximum enjoyment from the trip to the Pacific Coast. A "circle" trip by rail or air will cost no more than round-trip transportation if properly planned.

Travel information may be secured by writing to: R. A. Young, Chairman, 1954 General Meeting Transportation Committee; R. A. Young Company, 3905-$^1/_2$ San Fernando Road, Glendale 4, Calif.

Mt. Wilson Observatory operated jointly by the Carnegie Institution and the California Institute of Technology. The inspection trip to the mountain during the Summer and Pacific General Meeting will include the Observatory, the television transmitter stations, and the telephone office which serves the broadcasters

Directors to Tour Proposed Engineering Building Sites

Preceding its spring meeting in Chicago, Ill., on April 7, 1954, the AIEE Board of Directors will tour proposed sites in that area for a new engineering societies building. The program for April 6 will include visits to the Illinois Institute of Technology, the University of Chicago, and Northwestern University.

Members of the governing board or council of the other four Founder societies, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Chemical Engineers, and of United Engineering Trustees, have been invited to join the AIEE directors. The inspection tour will be followed by an informal dinner in the nature of an "executive session" with the AIEE as host.

Special Conference Planned on Military Communications

The AIEE Communication Division and the Institute of Radio Engineers (IRE) Professional Group on Communications Systems will be joint sponsors of a Symposium on Military Communications to be held on April 28, 1954, at the Western Union Auditorium, 60 Hudson Street, New York, N. Y.

Papers will be presented by engineers from the Coles Signal Laboratories, Fort Monmouth, N. J.; Bell Telephone Laboratories, Murray Hill, N. J.; and the Western Union Telegraph Company, New York City. Three subjects will be covered: the *ANTRC-24* radio relay, the *TCC* carrier telephone, and the *FGC-29* multichannel carrier telegraph equipments. The *ANTRC-*

24 and *TCC* equipment will be available for inspection.

Advance registration by mail will be accepted until Wednesday, April 21, 1954. Tickets will be mailed if application is received in time; otherwise, they will be held at registration desk. As registration facilities are limited, please register in advance if possible.

The fee for AIEE-IRE members is $2.00; nonmembers, $4.00. Mail applications with check or money order in the name of the American Institute of Electrical Engineers, Inc., to: P. G. Edwards, Bell Telephone Laboratories, Murray Hill, N. J.

Three Sessions Scheduled for Southern Textile Conference

A 2-day Conference on the Textile Industry will be held at the Georgia Institute of Technology, Atlanta, April 15–16, 1954. It will be sponsored by the AIEE Subcommittee on Textile Industry of the General Industry Applications Committee. Three sessions have been scheduled for this conference which include the presentation of approximately seven papers. The tentative program is as follows:

Thursday, April 15

9:00 a.m. Registration

Auditorium, High Tower Textile Building

10:00 a.m. Morning Session

Swaffield Cowan, presiding (Factory Insurance Association, Charlotte, N. C.)

Welcome: Blake R. Van Leer, president, Georgia Institute of Technology

Circuit Breakers as Applied to Textile Mills. *W. M. Emmons*, Westinghouse Electric Corporation, Atlanta, Ga.

High-Interrupting-Capacity Fuses. *J. C. Lebens*, Bussmann Manufacturing Company, New York, N. Y.

11:45 a.m. Discussion

12:30 p.m. Luncheon

Toastmaster. E. S. Lammers (Westinghouse Electric Corporation, Atlanta, Ga.)

Speaker to be announced

2:30 p.m. Afternoon Session

H. S. Colbath, presiding (Bibb Manufacturing Company, Macon, Ga.)

Multimotored Slasher Drive for Magnetic Amplifier Tension Control. *A. T. Bacheler, J. G. Stephenson*, Westinghouse Electric Corporation

Slasher Instrumentation. *J. E. MacConville*, Minneapolis-Honeywell Regulator Company, Atlanta, Ga.

New Developments in Electric Equipment of Value to Textile Mills. *R. C. Lathem*, Georgia Institute of Technology, Atlanta, Ga.

Open discussion

Friday, April 16

9:30 a.m. Morning Session

J. D. McConnell presiding (Cone Mills, Greensboro, N. C.)

NEMA Motor Rerating Program by General Electric Company. Speaker to be announced

Electrical Modernization in a Textile Mill. *W. L. Roark*, Avondale Mills, Sylacauga, Ala.

Title to be announced. *K. A. Richardson*, Bibb Manufacturing Company, Macon, Ga.

Panel Discussion on Mill Electrical Problems. *Moderator:* J. D. McConnell, Cone Mills; *Panel:* J. E. MacConville, Minneapolis-Honeywell; (Speaker to be announced), General Electric Company; J. D. Stephenson, Westinghouse Electric Corporation; W. L. Roark, Avondale Mills; K. A. Richardson, Bibb Manufacturing Company; R. C. Lathem, Georgia Institute of Technology

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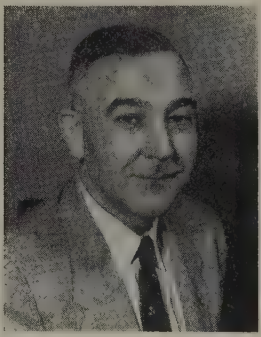
Spokane Section Hears Talk on Kemano-Kitimat Project

F. T. Matthias, assistant manager, British Columbia Project, Aluminum Company of Canada, Ltd., Vancouver, B. C., was guest speaker at a joint meeting of the Spokane Sections of the AIEE and the American Society of Civil Engineers, February 19, 1954. Mr. Matthias discussed the features and construction problems of this Canadian hydroelectric and aluminum project.

Mr. Matthias said that the power plant being built at Kemano, 50 miles from Kitimat, eventually will have an installed capacity of 2,200,000 kw and will support an annual aluminum production of 550,000 tons.

More than 200 miles of access roads had to be built to reach the various parts of the sprawling development. Transportation of materials and equipment over 170 miles of mountainous country was a complex problem and helicopters were used widely to bring men and equipment to the high-voltage lines crossing the mountains.



F. T. Matthias

The Kitimat project really has three phases. Phase one involves the already finished Kenney Dam on the Nechanko River. This dam will impound waters from an area of nearly 5,500 square miles. This water will be sent 10 miles through a tunnel carved from solid rock to the Kemano powerhouse, also located underground. Power from Kemano will be transmitted to the Kitimat aluminum reduction plant.

Rated as one of the largest and most difficult engineering projects ever undertaken by private enterprise, the Kitimat project is slated to be in production late this year.

Over-all cost of the project, including the storage dams, underground powerhouse, and reduction plant, is estimated at about $500,000,000. Over 7,000 workers were employed on the project.

Mr. Matthias illustrated his talk with colored slides and movies. (*Editor's note: Details of the Kemano-Kitimat project have appeared in EE, Dec '52, pp 1153–5, and Feb '54, p 124.*)

Program Announced for Annual Rubber and Plastics Conference

The Sixth Annual AIEE Conference on Rubber and Plastics will be held at the Mayflower Hotel, Akron, Ohio, April 5–6, 1954. Chairman of the conference is A. G. Seifried, the secretary-treasurer is R. R. Sorelle, and R. D. Heyburn is chairman of the Local Arrangements Committee.

Current conference plans include an inspection trip to Plant 2 of the Firestone Tire and Rubber Company on April 6.

Registration fee for the Conference on Rubber and Plastics will be $2.50 for both members and nonmembers, with no charge for students. The proceedings booklet will be sold at $3.00 per copy.

The tentative conference program is

Monday, April 5

Keynote Speaker: John Grotzinger, Goodyear Tire and Rubber Company

Training Young Engineers. *Arthur Carpenter*, B. F. Goodrich Company

Magnetic Clutches and Brakes for Rubber and Processing Machine Drives. *A. E. Lillquist*, Cutler-Hammer Corporation

Preventive Maintenance of Large Electric Motors and Controls in Rubber Mills. *Kurt John*, U. S. Rubber Company

High-Voltage Motor Controllers for the Rubber Industry. *F. J. Render*, General Electric Company

Selection of Drives for the Continuous Processing of Plastic Films. *A. G. Payne*, Monsanto Chemical Company

Tuesday, April 6

Morning

Recent Developments in Insulation of Large Electric Machines. *G. L. Moses*, Westinghouse Electric Corporation

Magnetic Amplifiers for the Rubber and Plastic Industries. *John Santer*, Clark Controller Company

Today's Challenge in Human Relations. *B. H. Taylor*, B. F. Goodrich Company

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COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Division

Committee on Communication Switching Systems (*A. E. Frost, Chairman; William Keister, Vice-Chairman; Eric Brooke, Secretary*). The activities of this committee have been concerned mostly with the securing of suitable technical papers for presentation at General meetings of the Institute. The theme of this work has been to assemble papers on similar subjects so that each technical session would appeal to a particular group in the communication switching field.

A program has been prepared for the Summer and Pacific General Meeting with special emphasis on West Coast activities.

The Fall General Meeting is scheduled to be held in Chicago, Ill., during the same week as the U. S. Independent Telephone Association national convention. A program especially designed for the telephone engineers of the independent telephone companies is being prepared, as it was felt that this coinciding of dates would be of considerable advantage and make the opportunity available for the engineers of the independent telephone companies to attend AIEE sessions.

Preliminary work has begun on the preparation of a glossary of communication switching terms and phrases. With the large growth in the communication industry since the end of the war, a large number of new engineers have entered this field and particularly among the independent companies, this growth has been subject to some confusion in that there was no standard recognized publication or list of technical terms and phrases generally used. Also, the advancement of the art has necessitated the development of new items and the Communication Switching Systems Committee started collecting and editing, in view to issuing at some later date a publication including such technical terms, with the hope that it would help the new people in the industry and tend to standardize on the same terms throughout and thereby assist all communication engineers and eliminate possible misunderstanding and confusion.

Committee on Telegraph Systems (*E. F. Watson, Chairman; F. H. Cusack, Vice-Chairman; R. B. Shanck, Secretary*). A meeting of the committee was held at which plans for future activities were discussed and consideration given to a number of possible subjects for papers to be presented at future scheduled meetings.

Industry Division

Committee on Mining and Metal Industry (*W. R. Harris, Chairman; R. B. Moore, Vice-Chairman*). Future plans include a session on western mining at the 1954 Summer and Pacific General Meeting in Los Angeles, Calif., June 21–25, and sessions on mining and on the metal industry at the AIEE Fall General Meeting in Chicago, Ill., in October.

Committee on Electric Welding (*E. J. Limpel, Chairman; J. F. Deffenbaugh, Vice-Chairman; R. J. Krieger, Secretary*). The Subcommittee on Fundamental Arc Research (L. P. Winsor, chairman) is making arrangements to publish a "Bibliography on High-Pressure Electric Arcs," which soon will be offered for sale at a nominal cost through AIEE Headquarters.

The Subcommittee on Instrumentation for Resistance Welding (C. R. Dixon, chairman) still is engaged in defining the problems of measurements in resistance welding.

Power Division

Committee on Switchgear (*R. L. Webb, Chairman; J. D. Wood, Vice-Chairman; J. M. Geiger, Secretary*). All of the five subcommittees in the Switchgear Committee are active on important programs. Inasmuch as the space available would not permit a complete report on each subject, a brief mention only will be made of the several subjects assigned to each group for the information of the membership. The chairmen of the respective subcommittees will be pleased to receive comments from any member of the Institute who has constructive suggestions to make which will assist in the work underway.

Subcommittee on Power Circuit Breakers (*R. M. Bennett*). Though the present American Standards Association (ASA) standards on power circuit breakers have been revised recently, this subcommittee already is working and looking forward to the next revision which will include many improvements which could not be adopted earlier. The subcommittee, through its Working Group on Circuit Breaker Rating Methods, also is developing a new basis for rating circuit breakers, which it is hoped will improve the application procedure and clarify many questions of rating and testing which formerly have been confusing.

The first report on this subject was presented at the Winter General Meeting.

Low-Voltage Air Circuit Breaker Subcommittee (*F. W. McCloska*). This subcommittee has two major projects which are particularly active at this time. One is the problem of establishing American Standards for molded-case air circuit breakers. A working committee is now active on this problem. The second project is that of establishing recommended procedures for calculating d-c short-circuit currents as supplied from the various types of equipment which can be used for d-c supply. The industry has needed a guide on this complicated subject for some time and the subcommittee is pleased to report that good progress is being made.

Switches, Fuses, and Insulator Subcommittee (*K. J. C. Falck*). This subcommittee has a number of important projects in hand, notable among them being the preparation of a "Guide for Ice Testing of Disconnect Switches," the preparation of a proposed standard on load break disconnect switches up to the continuous current rating of the switch, the preparation of AIEE Standard Nos. *22* and *25* for possible future submission to ASA for adoption as an American Standard, and the investigation of capacitor switches with disconnecting-type switches.

Automatic Circuit Reclosures and Lined Sectionalizers Subcommittee (*A. Van Ryan*). This subcommittee recently revised AIEE Standard No. *50* to include standards on line sectionalizers. The standard is at the moment in the process of ballot in the Switchgear Committee. A number of comments received are being processed by the subcommittee.

Switchgear Assemblies Subcommittee (*C. P. West*). This subcommittee is particularly active at this time on an "Application and Operating Guide for Metalclad Switchgear Applied Outdoors." The problem in this case is that of solar radiation, and the resulting heat which creates high ambients inside the outdoor metal housing. An exhaustive study has been made on the subject and a progress report was presented to the Institute at the recent Winter General Meeting. As a result of comments received at that time the subcommittee is studying the problem further, so that its final report can be prepared.

AIEE Standard No. *27* which was prepared by this subcommittee and which deals with switchgear assemblies is now under letter-ballot in the Switchgear Committee for recommendation to the ASA as an American Standard.

Committee on Rotating Machinery (*E. I. Pollard, Chairman; M. L. Schmidt, Vice-Chairman; R. F. Edwards, Secretary*). This committee and most of its subcommittees met during the Winter General Meeting in New York, N. Y. The overcrowding and resultant large number of concurrent technical sessions at the Winter General Meeting were discussed at some length. It was generally agreed that most of the technical sessions planned for next year would be better attended at the Fall General Meeting in Chicago, Ill., and it is planned to hold about half of the committee's technical sessions there.

Subcommittee on Insulation. This subcommittee is working very actively on the preparation of test codes for insulation systems which will allow their classification by tests simulating operating conditions instead of an arbitrary and frequently inaccurate classification by chemical composition. AIEE Standard No. *1C*, "Test Code for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery," has been issued for trial use. A similar test code for form-wound coils is being prepared, a working group to review experience with the random-wound code has been appointed, and it is expected that there eventually will be codes for all commonly used winding constructions. A proposed "Insulation Maintenance Guide for Large A-C Machinery" is in review and will be released for trial use soon.

Subcommittee on Synchronous Machinery. The subcommittee now has three working groups. At its meeting in New York City on January 19, J. G. Noest reported considerable progress in the preparation of a "Guide for the Operation and Maintenance of Turbine Generators." This is a large undertaking, so that it will not be finished for some time in spite of very extensive work by the working group. A. C. Sugden reported that the group working on the revision of the "Test Code for Synchronous Machines," AIEE Standard No. *503*, has determined that extensive revisions are required and estimated that 1 year would be required to get it in shape to present to the Standards Committee. A new working group was formed to establish liaison with the AIEE members of the corresponding American Standards Association (ASA) committee to keep the subcommittee informed as to developments in the revision of ASA Standard *C-50*.

Subcommittee on Induction Machinery. The subcommittee has completed revision of AIEE Standard No. *500*, "Test Code for Polyphase Induction Machines," to include some modifications suggested by the ASA *C-50* committee. Since this test code is to be published as an AIEE publication and also as part of ASA Standard No. *C-50*, the final editing to satisfy all interests has taken considerable time. A subgroup has been appointed to study new and revised Standards proposed by other organizations and keep the subcommittee informed.

The subcommittee is planning two technical sessions for the Fall General Meeting and is considering the following subjects for symposia: d-c equivalent circuits for temperature rise of motors, motor loss, motor fault currents due to winding failures, specific industry motor applications.

Subcommittee on D-C Machinery. The subcommittee has completed and approved a new table of temperature rises for d-c machines based on the data presented in a large number of technical papers in recent years. Since the Institute does not publish standards for d-c machines, this table is essentially a recommendation to other standardizing organizations such as National Electrical Manufacturers Association and ASA. A working group has been established to revise AIEE Standard No. *501*, "Test Code for D-C Machines." It is hoped that procedures for measuring stray load loss can be a part of this revision.

Subcommittee on Single-Phase and Fractional-Horsepower Machinery. The task force which is revising AIEE Standard No. *502*, "Test Code for Single-Phase Motors," reported that its work is almost completed. It is expected that subcommittee and committee approval can be completed this year so that the revision can be recommended to the Standards Committee.

The subcommittee was joint sponsor with the AIEE Fort Wayne Section of a technical conference on the application of motors to air-moving equipment last October. The attendance was over 250, which is a marked increase from the first motor application conference at Dayton, Ohio. Preliminary work has been started on a third conference tentatively scheduled for the spring of 1955.

Subcommittee on Eletcric Couplings. There is at present no generally accepted standard for describing the characteristics and for rating electric couplings, clutches, and brakes. This subcommittee is working on such a standard but due to the wide variety of equipment involved, it appears that it will be some time before definite progress can be reported.

Science and Electronics Division

Committee on Electronic Power Converters (*A. Schmidt, Jr., Chairman; J. B. Pitman, Vice-Chairman; J. K. Dillard, Secretary*). A meeting of the committee was held at the Winter General Meeting on January 19, 1954.

International standards for rectifiers have not yet been agreed upon by the several participating nations in the International Electrotechnical Commission (IEC) and this committee will set up a working group to make recommendations to American Standards Association Committee *C-37* for guidance of the American delegation at the next IEC meeting. The 1954 IEC meeting will be held in September at Philadelphia, Pa.

A working group from the electronic converter circuit subcommittee has been set up to review the problem of fault-current calculation in rectifier circuits.

Another working group has been selected to bring up to date the standards on cool-cathode mercury-arc power converters.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, January 21, 1954

Albert F. Briggs (AM '33, M '39), section head, electrical department, Sun Oil Company, Beaumont, Tex., has been transferred to the grade of Fellow in the AIEE "for his contributions to the application of electric power and automatic controls in the oil industry, including pipe-line pumping, gathering systems, and loading installations." Mr. Briggs was born in Madison, Wis., on January 24, 1903, and after attending the University of North Dakota, graduated from Massachusetts Institute of Technology in 1928 with a bachelor of science degree in electrical engineering. After graduation he was employed by Stone and Webster, Inc., Boston Mass., and in 1930 joined Gulf States Utilities Company, Beaumont. From 1933 to 1934 he was a surveyor for the U.S. Coast and Geodetic Survey. In 1934 he became associated with Sun Oil Company, Beaumont, as assistant to the electrical superintendent. He assisted in layout of electrical installations and computation of cost estimates on jobs. During World War II he served in the U. S. Army, being discharged with the rank of lieutenant colonel. He returned to Sun Oil as electrical section head with responsibility for supervision of the electrical department, design and selection of electric equipment for pipe-line stations on 10-inch crude oil lines in Texas and Louisiana. From 1949 to 1950 he was loaned to the Mid-Valley Pipeline Company, St. Louis, Mo., as electrical engineer responsible for the electrical design of seven trunk stations, study and development of practical control system for engine-driven stations, study of pressure gauges, tank gauges, flow meter, and other metering instruments and their relation to the operation of a pipe-line station. He returned to Sun Oil in 1950 as section head, electrical department, with responsibility for selection and application of electric equipment in modernization program of trunk and gathering stations, design and selection of protective devices for pipe-line operation, design and construction of new power lines, and design and supervision of electric equipment installation in diesel-electric drilling barges. Mr. Briggs is a member of the Texas Society of Professional Engineers.

Nathan Cohn (AM '29, M '42), manager, West Central Region, Leeds and Northrup Company, Chicago, Ill., has been transferred to the grade of Fellow in the AIEE "for his contribution to the art of load and frequency control of large power systems." Mr. Cohn was born in Hartford, Conn., on January 2, 1907, and was graduated from Massachusetts Institute of Technology in 1927 with a bachelor of science degree. He joined Leeds and Northrup that year on their factory training course and in 1928 was assigned to the college visitation section responsible for sales of laboratory instruments to colleges. In 1929 he was made district manager, Technical Division, of the San Francisco (Calif.) Office of the company in charge of technical sales of Leeds and Northrup products in the San Francisco area. In 1937 he was transferred to Chicago as district manager there. He became manager of the West Central Region in 1951. Mr. Cohn's outstanding engineering contribution is represented by his development of a new area-wide generation control system for interconnected power systems. Mr. Cohn conceived the basic design for this control and holds the patent rights for it. It incorporates new computing circuits which permit spreading the regulation in an operating area, plus loading stations and units for optimum economy from present incremental schedules, while fulfilling the area's over-all regulating needs. Mr. Cohn has presented several papers before the American Power Conference and the Midwest Power Conference and has served on committees of the National Electrical Conference and the Pacific Coast Electric Association. He is a member of Eta Kappa Nu.

Harold L. Durgin (M '40), executive vice-president and director, Central Vermont Public Service Corporation, Rutland, has been transferred to the grade of Fellow in the AIEE "for his contributions to power generation and conservation of natural resources." Mr. Durgin was born in Benton, Maine, December 7, 1902, and was graduated from the University of Maine in 1924 with a bachelor of science degree in electrical engineering. After graduation he was associated first with the Central Maine Power Company, Augusta, and later, in 1926, with the New England Public Service Company, also in Augusta. He joined Central Vermont Public Service Corporation in 1929 as an electrical engineer. He became chief engineer in 1934, vice-president in 1943, executive vice-president in 1950, and was elected to the board of directors in 1951. Mr. Durgin designed the hydroelectric generator for the Hoosick Falls (N. Y.) Hydroelectric Generating Plant, and several other hydroelectric stations in the St. Johnsbury, Vt., area. He was chief engineer in charge of construction of the Weybridge Hydroelectric plant for his company in 1951 and also chief engineer in charge of construction of a 3-unit gas turbine power plant in Rutland. Mr. Durgin was closely associated

Albert F. Briggs

Nathan Cohn

Photo by Bachrach

Harold L. Durgin

with Grandpa's Knob Wind Turbine Project in 1940 to 1945. This was the first large wind turbine constructed with a capacity of 1,000 kw at a wind velocity of 30 mph. He was a pioneer in his company of carrier-current telephone telemetering, radio communication to all company divisions, modern system relaying, and the use of gas-turbine generation of the regenerative type. Mr. Durgin is past president of the Vermont Society of Engineers and is a registered professional engineer in Vermont, New Hampshire, and Maine.

Peter C. Goldmark (M '45), vice-president in charge of engineering, research and development department, Columbia Broadcasting System, New York, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions to television and to phonographic recording." Mr. Goldmark was born in Budapest, Hungary, December 2, 1906. He received his bachelor of science degree in 1930 and his doctorate in 1931, both from the University of Vienna. From 1931 to 1933 he was engineer in charge of television research, Pye Radio Ltd., Cambridge, England. He came to the United States in 1934 and worked as a consulting engineer in New York City. Since 1936 he has been associated with the Columbia Broadcasting System in various positions doing development work, especially in the fields of color television and the long-playing phonograph record. During World War II he was group leader in war research at the Radio Research Laboratory, Harvard University. Dr. Goldmark is perhaps best known for his pioneering work in color television. He directed the work of the Columbia Broadcasting System which resulted in a complete color television system of high merit. He was also a leader in the development of long-playing phonograph records and high-fidelity sound recording. In 1944 he was awarded the Technical Progress Medal by the Television Broadcasters Association "for work in the development of motion picture pickup equipment and electronic analysis and control of equipment for color television." He received the Morris Leibmann Memorial Prize of the Institute of Radio Engineers in 1945 for his contributions to television systems, particularly in the field of color. Dr. Goldmark is the author of numerous technical papers on television and recording systems. He is a fellow of the Institute of Radio Engineers, the Society of Motion Picture and Television Engineers, the Television Society (London, England),

and a member of the American Physical Society. He is serving on the AIEE Committee on Television and Aural Broadcasting Systems (1949–52, 1953–54) and has served on the Committee on Communication (1946–49).

Lewis H. Hardin (M '41), superintendent, outside lines, Savannah River Project, The Du Pont Company, Augusta, Ga., has been transferred to the grade of Fellow in the AIEE "for achievement in the electrical design of large hydroelectric generating stations and associated transmission lines." Mr. Hardin was born in Blacksburg, S. C., June 1, 1890, and was graduated from Clemson College in 1911 with a bachelor of science degree in electrical and mechanical engineering. After holding positions with the General Electric Company and the H. C. Frick Coke Company, he joined Mees and Mees, Consulting Engineers, Charlotte, N. C., in 1918 as chief electrical engineer and head of electrical department. In 1929 he became assistant to superintendent of construction, Texas Power and Light Company, Dallas, and in 1930 transferred to the Allied Texas Electric Service Company, Fort Worth, as head of the construction department. After a period with the Georgia Public Service Comission, the Georgia Power and Light Company, and the Federal Power Commission, he became senior electrical engineer, Tennessee Valley Authority, in 1936. In 1939 he became associated with the South Carolina Public Service Authority as principal electrical engineer. From 1946 to 1951 he was director of municipal utilities for Camden, S. C. Since 1951 he has been superintendent of outside lines department of the Savannah River Project. Mr. Hardin has been responsible for the design of many hydroelectric plants with associated transmission facilities throughout the South. He was directly responsible for the Tennessee Valley Authority's Chickamauga Project and also made the basic layout of the Kentucky project. As chief electrical engineer, South Carolina Public Service Authority, he was responsible to the chief engineer for design and supervision of construction of the Santee-Cooper Hydroelectric Project and transmission system. At present he is one of two key men in the electrical department for construction of the transmission system and related switching facilities and control of the Savannah River Project for the Du Pont Company as contractor for the Atomic Energy Commission. Mr. Hardin is a member of the American Water Works Association and the South Carolina Society of Engineers.

Earl B. Paxton (AM '22, M '25), supervisor, electrical and related standards, standards services department, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions to the formulation and organization of standards in the electrical field, the promotion of their acceptance and use by industry, and their co-ordination with other national and international codes." Mr. Paxton was born in Loveland, Ohio, on April 20, 1895, and was graduated from the University of Florida in 1920 with a bachelor of science degree in electrical engineering. After receiving his degree, Mr. Paxton started his professional career with the Westinghouse Electric and Manufacturing Company (now Westinghouse Electric Corporation). In 1921 to further his technical education he obtained a position as instructor in electrical engineering at Texas Agricultural and Mechanical College, College Station, and at the same time took postgraduate work. The following year he went to Schenectady with the General Electric Company. His work covered developments in electric machines such as welding generators, large turbine and waterwheel generators, and mercury-arc rectifiers, and the development of industry standards for electric machines and apparatus. In 1931 he was transferred to the standards department and assigned the responsibility of supervising the approval of equipment by testing laboratories and by code-enforcing authorities. In 1938 because of his ability and experience in standards work, he was placed in charge of the section of the standards department respon-

Peter C. Goldmark

Lewis H. Hardin

Earl B. Paxton

sible for standardization with various outside organizations for national and local codes and ordinances affecting the installation of equipment, for relations with code-enforcing authorities, and for supervision of submittal of equipment to approval laboratories. In 1949 he was put in charge of the electrical section of the Standards Division, responsible for general standardization in the electrical field in the company and with various national organizations and codes and approval authorities. In 1953 he was named supervisor, electrical and related standards, with responsibilities and authority for developing and administering standardization activities. Mr. Paxton is a member of Phi Kappa Phi, the National Fire Protection Association, and the International Association of Electrical Inspectors. He has served on the AIEE Committees on Electrical Machinery (1925–27, 1928–34, 1935–38) and Standards (1931–54, Chairman, 1950–52) and on the American Standards Association Council and Electrical Standards Committee.

An item on J. K. Ostrander, also transferred to the grade of Fellow by the Board of Directors on January 21, 1954, will appear in a future issue.

AIEE PERSONALITIES.....

F. A. Cowan to Be Awarded 1953 Lamme Medal

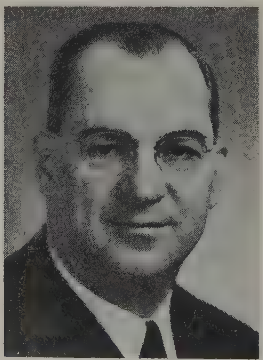
Frank A. Cowan (M '29, F '45), assistant director of operations, long lines department, American Telephone and Telegraph Company, New York, N. Y., has been awarded the AIEE Lamme Medal for 1953 "for his outstanding contributions to long distance communication and the development of modulating and transmission measuring apparatus of original design and wide application." Mr. Cowan was born in Escatawpa, Ala., August 30, 1898, and received his bachelor of science degree in electrical engineering from the Georgia Institute of Technology in 1919. A few months after graduation he joined the long lines department, American Telephone and Telegraph Company, Atlanta, Ga., and in 1922 was transferred to its engineering department in New York. All of his Bell System service since has been spent in that city. Mr. Cowan's early assignments involved him in transmission testing methods and field trials of new long-distance communications systems. He also was concerned with the development of such special services as network program transmission, overseas radio telephony, and the transmission of pictures by wire. In 1928 Mr. Cowan was appointed engineer of transmission for long lines. In 1940 he was placed in charge of the transmission section of the operation and engineering department of the company. Nine years later he returned to long lines where he is in charge of the engineering staff. Of late years his work has included the engineering aspects of long lines activities arising from regulatory proceedings. Mr. Cowan's scientific activities have caused him to be granted 17 patents while still another is pending. Prominent among these are bridge- and ring-type modulators and demodulators widely used today in communications systems. Another of his inventions, first built in his own workshop and now employed throughout the Bell System, is a direct reading telegraph transmission measuring set. In 1946 Mr. Cowan was the U. S. delegate at meetings of the International Consulting Committee on Telephony and is a senior member of the Institute of Radio Engineers. He has served on the AIEE Committees on Technical Program and Award of Institute Prizes.

A. C. Monteith Nominated for Institute President

Alexander Crawford Monteith (AM '25, M '40, F '45), vice-president in charge of engineering and research, Westinghouse Electric Corporation, Pittsburgh, Pa., has been nominated for the presidency of the AIEE for the 1954–55 term. Born on April 10, 1902, in Brucefield, Ont., Canada, Dr. Monteith received his bachelor of science degree in electrical engineering from Queen's University in 1923. In 1948 he received an honorary degree of doctor of laws from Queen's University. Dr. Monteith's 30-year engineering and business career began in 1923 when he joined Westinghouse at East Pittsburgh as a graduate student on the training program. The following year he was assigned to the central station engineering department, where he became an expert in power station auxiliaries, power system transmission, distribution, and related fields. For several years he acted as an engineering supervisor and consultant on power system problems to various utilities serving the central part of the United States. He became manager of the department in 1938. While holding this position he was awarded the Westinghouse Order of Merit in 1940. In 1941 he was named manager of the entire industry engineering department. In 1945 he assumed responsibility for the headquarters engineering departments of Westinghouse and became director of education as well. In this same year he was appointed secretary of the Westinghouse Educational Foundation. In 1948 he was elected to his present executive position as vice-president. He also became chairman of the Westinghouse Educational Foundation that year. Dr. Monteith is a member of The American Society of Mechanical Engineers and was elected an honorary member of that society in 1953. In addition he has served on several American Standards Association committees and is a member of the Engineers Society of Western Pennsylvania, the American Society for Engineering Education, the International Conference on Large Electric High-Tension Systems (CIGRE), and Tau Beta Pi. He was a charter member of the Engineering Manpower Commission of Engineers Joint Council and has served in various functions with the Engineers' Council for Professional Development. An unusually active member of the AIEE, Dr. Monteith has served as a director (1947–51), as secretary and chairman of the Pittsburgh Section (1946–47, 1947–48), and on the following Institute committees: Power Generation (1938–44, Chairman, 1942–44); Protective Devices (1940–42); Standards (1941–51, Chairman, 1944–45); Technical Program (1942–45); Planning and Co-ordination (1944–45, 1953–54); Lamme Medal (1946–49, 1952–55, Chairman, 1953–54); Education (1946–48); Edison Medal (1947–51); Executive (1947–49, 1950–51); Management (1947–54, Chairman, 1949–51); Finance (1947–49); Board of Directors (1947–51); and Liaison Representative on the Standards Committee (1951–54).

Photo by Bachrach

Frank A. Cowan



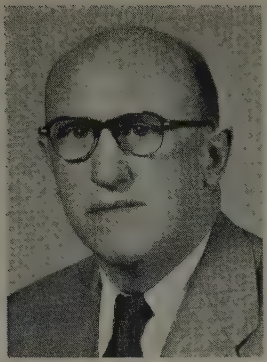
A. C. Monteith

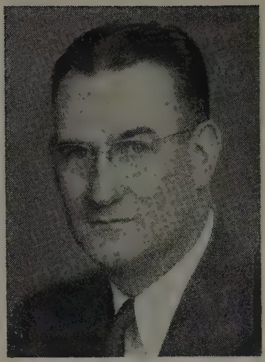
G. J. Crowdes

Vice-Presidential Nominees Are Crowdes, Neubauer, Summers, Sharp, and Walker

George Jackson Crowdes (AM '21, M '32, F '46), chief engineer, Simplex Wire and Cable Company, Cambridge, Mass., has been nominated to serve the Institute as Vice-President representing the North Eastern District (number 1). Mr. Crowdes was born in Roxbury, Mass., on June 28, 1899, and attended Lowell Institute at the Massachusetts Institute of Technology. He has been with Simplex Wire and Cable since 1918, and has served successively as research engineer, cable engineer, assistant chief engineer, and chief engineer. Mr. Crowdes is a member of the Insulated Power Cable Engineers Association, American Railroad Association, American Signal Association, and has served on committees of the American Standards Association, National Electrical Manufacturers Association, and the American Society for Testing Materials. He is a former secretary and

J. P. Neubauer


C. M. Summers


S. M. Sharp

J. R. Walker

chairman of the Boston Section of the AIEE and is serving as secretary, District 1. He is serving on the AIEE Committee on Electronics (1945–54) and has served on the Committee on Special Communications Applications (1951–53).

John Paul Neubauer (AM '27, M '46), division engineer, electrical engineering department, Consolidated Edison Company of New York, Inc., New York, N. Y., has been nominated to serve the Institute as Vice-President representing the New York City District (number 3). Mr. Neubauer was born on November 16, 1904, in Bridgeport, Conn. He was graduated from Rensselaer Polytechnic Institute in 1926 with a degree of electrical engineer and from Yale University in 1928 with a degree of master of science in electrical engineering. He was employed by the New York Edison Company as a tester from 1926 to 1927 and in 1928 joined the Brooklyn Edison Company (now the Consolidated Edison Company) as an engineer in the outside plant bureau. He was appointed division engineer in charge of electric planning in 1946. Mr. Neubauer is a licensed professional engineer in New York. He has served the AIEE as secretary of District 3 (1952–54), chairman of the New York Section (1951–52), and on the following Institute committees: Public Relations (1950–52); Headquarters (1952–54, Chairman, 1952–54); Sections (1952–54); and Transmission and Distribution (1952–54).

Claude Menta Summers (AM '30, M '39, F '49), manager, Fort Wayne Laboratory, General Electric Company, Fort Wayne, Ind., has been nominated to serve the Institute as Vice-President representing the Great Lakes District (number 5). Mr. Summers was born in Boone County, Mo., September 1, 1903, and graduated from the University of Colorado with a bachelor of science degree in electrical engineering in 1927. He received the degree of electrical engineer in 1933, also from the University of Colorado. After graduation, he joined the General Electric Company test course in Fort Wayne. From 1928 to 1931 he was design engineer associated with the specialty transformer department. In 1931 he transferred to the Fort Wayne Laboratory of the company and served as development engineer until 1944. From 1944 to 1945 he was section engineer of the electrical section of the Laboratory. In 1945 he was made assistant engineer and in 1949 became manager. Mr. Summers has served as secretary and chairman of the Fort Wayne Section of the AIEE and on the Institute Committees on Electronics (1947–52) and Membership (1952–54).

Samuel Miles Sharp (AM '26, M '42, F '48), vice-president and chief engineer, Southwestern Gas and Electric Company, Shreveport, La., has been nominated to serve the Institute as Vice-President representing the South West District (number 7). Mr. Sharp was born October 14, 1901, in Alma, Ark., and was graduated from the University of Arkansas in 1923 with a degree in electrical engineering. After a year on the Westinghouse student course, he joined the East St. Louis (Ill.) Light and Power Company as distribution engineer. In 1925 he became electrical design engineer for Minnesota Power and Light Company, Duluth. From 1926 to 1932 he was electrical engineer with Central and Southwest Utilities Company, Dallas, Tex. In 1932 he began his association with Southwestern Gas and Electric Company as electrical superintendent, Louisiana Division. He became chief engineer of the company in 1941. During World War II, Mr. Sharp served as a lieutenant colonel in the U. S. Army Signal Corps. After the war he returned to his position as chief engineer and was elected a vice-president of the company in 1948. Mr. Sharp is a registered professional engineer in Louisiana and Texas. He has served as chairman of the Shreveport Section of the AIEE (1947–48) and on the Institute Committee on Sections (1952–54).

John Robert Walker (AM '28, M '35, F '48), chief, Power Division, Region 6, U. S. Bureau of Reclamation, Billings, Mont., has been nominated to serve the Institute as Vice-President representing the North West District (number 9). Mr. Walker was born in Erie, Pa., November 30, 1901, and was graduated from the Rensselaer Polytechnic Institute in 1924 with the degree of electrical engineer. Following his graduation he was employed by the New York Telephone Company, Albany, as an equipment engineer. From 1924 to 1926 he served as a circuit engineer in the signal department, New York Central Railroad Company, Albany. He joined the U. S. Bureau of Reclamation, Denver, Colo., in August 1926, as an electrical engineer. His service with the Bureau was interrupted from 1940–45 when he served as a lieutenant colonel, U. S. Army, in the Pacific Theater. Upon discharge, he resumed work with the

L. F. Hickernell

R. E. Kistler

E. S. Lammers, Jr.

W. J. Barrett

Bureau of Reclamation in Billings in his present capacity. Mr. Walker has served as secretary of the AIEE Denver Section (1938–40) and as chairman of the Montana Section (1949–50).

Hickernell, Kistler, and Lammers Nominated for Directorships

Latimer Farrington Hickernell (AM '25, M '27, F '34), chief engineer, Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., has been nominated to serve on the AIEE Board of Directors. Mr. Hickernell was born on March 22, 1899, in Middletown, Pa., and received the degree of bachelor of arts from Grinnell College in 1920 and that of bachelor of science in electrical engineering from Massachusetts Institute of Technology in 1922. While in college he was employed by the Iowa Light, Heat and Power Company, Grinnell, in various capacities. Upon graduation from Massachusetts Institute of Technology, he joined the graduate student engineer course of the General Electric Company, Lynn, Mass. In 1923 he entered the engineering department of the Consumers Power Company, Jackson, Mich., as assistant investigations engineer in the electrical department. In 1924 he became assistant investigations engineer of the successor company, the Commonwealth Power Corporation of Michigan. He became general engineer in the electrical engineering department in 1927. Stevens and Wood, Inc., succeeded this company in 1929 and in 1930 this concern was in turn succeeded by Allied Engineers, Inc. Mr. Hickernell continued as general engineer with these concerns until the disbandment of the latter organization in 1931. In that year he joined Anaconda Wire and Cable Company as electrical engineer. He became chief engineer in 1933. He has served on many committees of the National Electric Light Association, the American Society for Testing Materials, National Research Council, and the Insulated Power Cable Engineers. Mr. Hickernell is serving as a Director of the AIEE and has served on the following Institute committees: Electrical Machinery (1929–33); Protective Devices (1929–32); Transmission and Distribution (1930–42, 1945–47); Publications (1934–35, 1951–54); Board of Examiners (1941–54); Insulated Conductors (1947–54, Chairman, 1947–49); Public Relations (1952–54); Standards (1947–49); Technical Program (1947–50); Power Division (1947–53, Chairman, 1949–51); Planning and Co-ordination (1949–50, 1952–54); Award of Institute Prizes (1949–50); Technical Advisory (1950–52); Technical Operations (1952–54, Chairman, 1952–54); and Board of Directors (1953–54).

Roy Emanuel Kistler (AM '17, M '30, F '46), assistant chief engineer, Pacific Telephone and Telegraph Company, Seattle, Wash., has been nominated to serve on the AIEE Board of Directors. Mr. Kistler was born on May 15, 1893, at Moscow, Idaho, and was graduated from Stanford University in 1915 with a degree in electrical engineering. From 1915 to 1917 he was employed in the testing department of the General Electric Company at Schenectady, N. Y., and Pittsfield, Mass. During World War I he served as a lieutenant in the U. S. Army Corps of Engineers in the United States and France. He joined the Pacific Telephone and Telegraph Company, San Francisco, Calif., as an engineer in 1919. He was transferred to Seattle in 1925 and has successively held the positions of protection engineer, transmission and protection engineer, and assistant chief engineer. Mr. Kistler has served as chairman of the Seattle Section of the AIEE (1938–39) and on the Institute Committees on Sections (1946–54) and Registration of Engineers (1947–49).

Edwin Stanton Lammers, Jr. (M '34, F '53), electronics engineering supervisor, Westinghouse Electric Corporation, Atlanta, Ga., has been nominated to serve on the AIEE Board of Directors. Mr. Lammers was born in Dallas, Tex., on August 11, 1892, and was graduated from Texas Agricultural and Mechanical College in 1913 with a bachelor of science degree in electrical engineering. He joined Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) the same year on their graduate student course, after completion of which he became a design engineer in the Industrial Control Division in 1915. Two years later he became section engineer in charge of steel mill control design. In 1919 he joined the electrical engineering department of the National Tube Company, a subsidiary of the United States Steel Corporation located at Lorain, Ohio, remaining there for 4 years. He returned to Westinghouse at East Pittsburgh as the industrial control supervisor of the Industrial Sales Division. In October 1926 he was transferred to the Atlanta Office as a consulting and application engineer, handling industrial electrical engineering problems over the Southeastern District of the company. He became electronics engineering supervisor in 1944. Mr. Lammers is a member of the Institute of Radio Engineers, Iron and Steel Electrical Engineers, and the Georgia Engineering Society. He has served the AIEE as vice-president, District 4 (1951–53), and as chairman of the Georgia Section (1949–50) and on the Science and Electronics Division Committee (1952–53).

W. J. Barrett Renominated as Institute Treasurer

Walter J. Barrett (M '36, F '50), electrical co-ordination engineer, New Jersey Bell Telephone Company, Newark, has been renominated to serve the AIEE as Treasurer. Mr. Barrett was born in Brooklyn, N. Y., January 10, 1899, and was graduated from the Polytechnic Institute of Brooklyn in 1920 with the degree of electrical engineer. Upon graduation, he entered the employ of the American Telephone and Telegraph Company, New York, N. Y., and in 1924 was transferred to the staff of the transmission engineer for the company. In 1930 Mr. Barrett became a supervisor in the engineering department, New Jersey Bell Telephone Company, Newark, and worked in that capacity until his appointment as electrical co-ordination engineer in 1943. Mr. Barrett has been serving as Institute Treasurer since 1953, and has served also as a director (1949–52), District 3 secretary (1948–49), New York Section secretary and chairman, and on many AIEE committees. Mr. Barrett is vice-president of United Engineering Trustees and a member of the executive committee of Engineers Joint Council. (*A complete biography of Mr. Barrett appeared in EE, Dec '52, p 1151.*)

F. D. Newbury (AM '07, F '21, Member for Life), retired, Westinghouse Electric Corporation, New York, N. Y., has been appointed Assistant Secretary of Defense for Applications Engineering. The functions of the Applications Engineering Office are to foster the engineering of military equipment for maximum ease of manufacture and maintenance, using standard materials and parts wherever possible, with a view to production of the best equipment for the least money. Application Engineering responsibility ordinarily begins with the completion of laboratory and engineering field tests of prototypes, and continues through operational suitability or user tests and the production engineering problems which come up during the entire production phase. Mr. Newbury had been with Westinghouse 45 years before his retirement. He has served on the following AIEE committees: Edison Medal (1920–22, 1942–47); Electrical Machinery (1920–31, Chairman, 1927–28); Lighting and Illumination (1919–20); Power Stations (1918–22); Standards (1919–35, Chairman, 1928–31); Meetings and Papers (1921–22, 1926–28); Members-for-Life Fund (1944–50). Mr. Newbury also has served on the U. S. National Committee of the International Electrotechnical Commission, and on the Standards Council and Electrical Standards Committee of the American Standards Association.

W. R. G. Baker (AM '19, F '47), vice-president and general manager, Electronics Division, General Electric Company, Syracuse, N. Y.; **M. J. Kelly** (M '26, F '31), president, Bell Telephone Laboratories, Inc., New York, N. Y., and **Rheinhold Rudenberg** (M '38, F '50), Gordon McKay professor of electrical engineering, Harvard University, Cambridge, Mass., were inducted into Eminent Membership of the Eta Kappa Nu Association recently. Dr. Baker was chosen for Eminent Membership in recognition of his technical achievements and administrative leadership in the field of electronics; Dr. Kelly was selected for his distinguished service in directing scientific research and his many contributions to national scientific and military policy, and Dr. Rudenberg for his distinguished record as Gordon McKay professor of electrical engineering at Harvard University and his research and design of electric motors, conductors, and transient performance of power systems.

J. D. Ryder (AM '40, F '51), head of the electrical engineering department, University of Illinois, Urbana, has been named dean of the School of Engineering at Michigan State College, East Lansing. The appointment is effective July 1, 1954. Dr. Ryder was born in Columbus, Ohio, and received his bachelors and masters degree from Ohio State University. His doctor of philosophy degree was awarded by Iowa State College. After receiving the masters degree, he worked with the General Electric Company in the development of electronics. In 1931 he became supervisor of the electronic section of the Bailey Meter Company's research laboratory in Cleveland, Ohio. In 1941, Dr. Ryder became assistant professor at Iowa State College, Ames, and in 1944 as full professor, he was placed in charge of electronics courses. In 1947, he became assistant director of the Iowa Engineering Experiment Station. He became professor and head of the electrical engineering department at the University of Illinois in September 1949. Dr. Ryder is a member of the Institute of Radio Engineers, American Society for Engineering Education, Sigma Xi, Tau Beta Pi, Eta Kappa Nu, Pi Mu Epsilon, and Phi Kappa Phi. He has served on the board of directors of the National Electronics Conference and on the following AIEE committees: Electronics (1946–54); Education (1949–54, Chairman, 1952–54); Computing Devices (1951–54); Fortescue Fellowship (1951–54); Student Branches (1951–52, 1953–54); and Technical Operations (1952–54).

S. R. Warren, Jr. (M '41, F '53), professor of electrical engineering and vice-dean, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, has been named assistant vice-president in charge of undergraduate engineering studies at the university. **J. G. Brainerd** (M '39, F '47), chairman of the division of physical science, Graduate School of Arts and Sciences, University of Pennsylvania, has been appointed director of the Moore School of Electrical Engineering. Dr. Warren is a very active member of the AIEE, having served on the following committees: Education (1947–54); Therapeutics (1949–51); Electrical Techniques in Medicine and Biology (1951–54, Chairman, 1951–53); Science and Electronics Division (1951–54); Award of Institute Prizes (1952–54); and Code of Principles of Professional Conduct (1953–54). Dr. Brainerd has been a member of these Institute committees: Basic Sciences (1940–49, 1950–54, Chairman, 1944–46); Standards (1944–46, 1949–50); Technical Program (1944–46, 1949–50); Computing Devices (1948–54, Chairman, 1949–51); and Science and Electronics Division (1949–51).

F. J. Leerburger (AM '28, F '51), consulting engineer, New York, N. Y., has been appointed chief engineering consultant to the Power Authority of the State of New York. A former principal valuation engineer of the New York Public Service Commission, Dr. Leerburger is a graduate in electrical engineering from Columbia University, where he subsequently received his doctoral degree. In World War II Dr. Leerburger served in the U. S. Navy with the rank of captain. Since 1950 he has been on the faculty of the graduate school of Public Administration and Social Service of New York University.

P. L. Hoover (AM '24, M '44), head of the department of electrical engineering, Case Institute of Technology, Cleveland, Ohio, has asked to be relieved of his administrative duties as head of the department. Professor Hoover will remain on the teaching staff as professor of electrical engineering. Dr. Hoover received his bachelor of science degree in physics at Carnegie Institute of Technology in 1921. In 1923 he received his masters degree in physical science at Harvard University. After study in Germany, Austria, and at the Sorbonne in Paris, he returned to Harvard where he received his doctorate in 1926. He first joined the Case faculty in 1927 as an assistant professor. In 1930 he joined the staff at Rutgers and returned to Case as professor of electrical engineering in 1939. Dr. Hoover has served on the following AIEE committees: Student Branches (1942–43, 1947–49); Electronics (1943–44); and Basic Sciences (1953–54).

L. V. Bewley (AM '27, F '47), head of the department of electrical engineering, Lehigh University, Bethlehem, Pa., has been named dean of the College of Engineering. A member of the faculty since 1950, Mr. Bewley has served as secretary of the Lehigh University engineering executive committee for the past 2 years. Before joining the Lehigh staff, he served as research engineer of the General Electric Company for 17 years. An honor graduate of the University of Washington in 1923, he received his master of science degree in electrical engineering from Union College in 1928. During World War II, he served as an artillery officer and as a staff officer with the rank of colonel. Professor Bewley is the author of five textbooks and has received many honors, including the Coffin Award from General Electric and the Hillman Award from Lehigh. He is a member of the American Society of Engineering Education, Tau Beta Pi, and Sigma Xi. He has served on the following AIEE committees: Basic Sciences (1940–41, 1949–52); Education (1941–42); and Board of Examiners (1952–53).

R. P. Brown (AM '10, M '13), Member for Life), vice-president and chairman of the board, Industrial Division, Minneapolis-Honeywell Regulator Company, Philadelphia, Pa., has retired. Mr. Brown will continue to serve as a director of the company. He has served on the AIEE Committee on Instruments and Measurements (1924–25).

R. H. Barclay (AM '14, F '28, Member for Life), vice-president in charge of engineering, J. G. White Engineering Corporation, New York, N. Y., has been elected a director of the corporation. Mr. Barclay has been associated with J. G. White since 1941, becoming engineering manager in 1950, and vice-president in charge of engineering in 1953. (*A complete biography of Mr. Barclay appeared in EE, Aug 53', p 719.*)

E. W. Engstrom (F '49), vice-president in charge of research, RCA Laboratories Division, Radio Corporation of America, Princeton, N. J., has been promoted to executive vice-president in charge of the RCA Laboratories Division.

OBITUARIES

Alexander Morton MacCutcheon (AM '12, M '15, F '26, Member for Life), retired, Reliance Electric and Engineering Company, Cleveland, Ohio, died March 3, 1954, in Orlando, Fla. Mr. MacCutcheon a past president (1936–37) of the AIEE and 1947 Lamme Medalist, retired as senior vice-president of Reliance in 1946. Mr. MacCutcheon was born at Stockport, N. Y., December 31, 1881, and after graduation from the State Normal College in 1901 taught mathematics and science in high schools until in 1904 he entered the electrical engineering course in Columbia University, from which he was graduated in 1908. He was employed by the Crocker Wheeler Company, Ampere, N. J., from 1909 to 1914, when he took charge of all new design work for the Reliance Electric and Engineering Company. He was appointed chief engineer in 1917, but in the same year entered the U. S. Navy and was a lieutenant at the time of his release from active service in 1919. He then returned to his former position and the following year was elected a director of the company. In 1923 he became vice-president in charge of engineering and in 1945 became senior vice-president, a position from which he retired in 1946, although he remained available to the company as a consultant. Mr. MacCutcheon was awarded the 1947 AIEE Lamme Medal "for his distinguished accomplishments in the development of motors for industrial needs, notably in the steel industry." He was a member of the Association of Iron and Steel Electrical Engineers, in which he had served on various committees. Mr. MacCutcheon was recognized as an authority on the subject of motor applications for steel mill auxiliaries, and in the National Electrical Manufacturers Association was one of the leaders in bringing about the standardization of uniform motor mounting dimensions. He was active in the development of the Cleveland Technical Societies Council, and had been AIEE representative on the U. S. National Committee of the International Electrotechnical Commission and the Electrical Standards Committee and Standards Council of the American Standards Association. Mr. MacCutcheon was a director of the Institute (1928–32) and had served on the following committees: General Power Applications (1916–18, 1924–33, Chairman, 1925–28); Electrical Machinery (1924–34); Meetings and Papers (1925–29); Standards

Alexander Morton MacCutcheon

(1922–36, Chairman, 1931–34); Electric Welding (1928–30); Applications to Iron and Steel Production (1928–33); Edison Medal (1929–31, 1936–39); Lamme Medal (1934–37, 1951–54, Chairman, 1935–36); John Fritz Medal Board of Award (1936–40); Institute Policy (1937–40, Chairman, 1937–39); Code of Principles of Professional Conduct (1938–39); Constitution and Bylaws (1939–40); and Planning and Coordination (1939–40).

Harold Willson Rogers (AM '12, Member for Life), retired, General Electric Company, Schenectady, N. Y., died January 21, 1954. Mr. Rogers retired as engineering consultant, Paper and Textile Division, General Electric, on May 1, 1948, after 42 years of service. Born in Hartford Conn., April 28, 1883, Mr. Rogers was graduated from Worcester Polytechnic Institute in 1906 with a bachelor of science degree in electrical engineering. He joined the General Electric test course the same year. He was transferred to the power and mining department, now the industrial engineering section, in 1907 and had been engaged in industrial application engineering from that time. In 1908 he was assigned to study the electrification of steam power shovels and his work at that time established the pattern for the system now used on all important excavating machinery. Subsequently he undertook the development of the sectionalized paper machine drive, and tested and analyzed paper-making machinery so completely and thoroughly that his power constants are recognized as standard for the industry. In 1922, Mr. Rogers was placed in charge of the industrial manufacturers section of the industrial engineering department. He later became engineer of the Paper and Textile Division. In 1947 Mr. Rogers was appointed engineering consultant of the Paper and Textile Division. Since his retirement, Mr. Rogers had prepared a complete application data book on the paper industry. He had served on the following AIEE committees: General Power Applications (1920–26, 1930–38, Chairman, 1931–38); Industrial Power Applications (1938–42); and Technical Program (1936–38).

James Austin Ward (AM '18), president, California-Pacific Utilities Company, San Francisco, died February 1, 1954. Mr. Ward was born in Monticello, Ind., August 8, 1880, and attended Purdue University and Armour Institute of Technology. From 1903 to 1908 he was employed as an engineer with S. A. Oliver, Sturgis, S. Dak., and Crawford, Nebr. He was engineer and manager and director of Natrona County Electric Company, Casper, Wyo., from 1909 to 1918. During World War I he served as a first lieutenant in the Corps of Engineers, U. S. Army. In 1919 he was associated with A. M. Hewes Company, Chicago, Ill., as efficiency engineer. In 1920 he became manager and engineer of Huron (S. Dak.) Light and Power Company, later becoming vice-president and general manager of Northwestern Public Service Company (successor of Huron Light and Power). He was vice-president and general manager of Ohio Electric Power Company, Sidney, from 1927 to 1930. In 1930 he was named vice-president and director of Republic Electric Power Company, San Francisco, serving in that capacity until 1933 when he was elected president and director. He continued in that capacity with California-Pacific Utilities Company, the successor to Republic Electric Power.

Nicholas J. Kelly (AM '22, M '29), chief engineer, Bureau of Gas and Electricity, Department of Water Supply, Gas, and Electricity, City of New York, N. Y., died February 21, 1954. Mr. Kelly was born in New York City, July 19, 1890. From 1905 to 1914 Mr. Kelly was a draftsman for a concern of consulting engineers. For the next 3 years he was an inspector of light and power for New York City, and then served in the U. S. Army during World War I. After the war, he was an engineer and an estimator for several electrical companies and engineering concerns until he was named chief engineer of the municipal bureau. It was under Mr. Kelly's direction that the sodium lighting system on the Belt Parkway in New York was begun in 1940. He was a leader of groups that pressed for more lights in dimly lit streets and for illumination on side streets as well as main highways. Mr. Kelly was a member of the New York State Society of Professional Engineers, the National Society of Professional Engineers, the Illuminating Engineering Society, and the Society of Municipal Engineers.

Thomas Barclay Whitson (AM '28), director of engineering and member of the board, James G. Biddle Company, Philadelphia, Pa., died January 23, 1954. Mr. Whitson was born in Philadelphia, Pa., on July 14, 1894, and was graduated from Haverford College in 1917 with a bachelor of science degree. After a year on the General Electric test course, he served in France with the American Friends Service Committee at the close of World War I. He came to the James G. Biddle Company in 1922 after having worked at the Exide Battery Company and the Rubicon Company. Mr. Whitson was a member of the Franklin Institute, the Mineralogical Society of Pennsylvania, and the Engineers Club of Philadelphia.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of February 18, 1954, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Akeley, L. T., engineer, General Electric Co., West Lynn, Mass.
Boyd, W., electrical engineer, Aluminum Co. of America, Pittsburgh, Pa.
Brenn, E. A., electrical engineer, Aluminum Co. of America, Pittsburgh, Pa.
Capps, J. H., design engineer, General Electric Co., Fort Wayne, Ind.
Carty, J. P., area operations supervisor, Western Union Telegraph Co., Philadelphia, Pa.
Cassel, W. M., senior engineer, Philadelphia Electric Co., Philadelphia, Pa.
Childs, E. W., Jr., electrical engineer, Alabama Power Co., Birmingham, Ala.
Desor, R. C., engineer, Wm. C. Feige, Jr. & Co., Baltimore, Md.
Doescher, E. B., senior engineer, Northern States Power Co., Minneapolis, Minn.
Dyson, L. M., assistant professor, Louisiana Polytechnic Institute, Ruston, La.
Eaton, R. A., supervisor, fire control section, San Francisco Naval Shipyard, San Francisco, Calif.
Eichmuller, A. J., chief electrical engineer, Adache & Case, Engineers, Cleveland, Ohio
Estelle, W. E., assistant professor, U. S. Naval Academy, Annapolis, Md.
Flournoy, L. C., distribution superintendent, Alabama Power Co., Birmingham, Ala.
Foster, W. W., lieutenant colonel, Chief Fire Control Branch, Aberdeen Proving Ground, Md.
Freeland, W. T., owner, Freeland Products Co., New Orleans, La.
Garst, C. R., electrical superintendent, J. M. Huber Corp., Borger, Tex.
Glover, C. A., service engineer, West Texas Utilities Co., Abilene, Tex.
Harvey, G. L., section supervisor, Sandia Corporation, Albuquerque, N. Mex.
Hazen, D. F., Jr., traffic manager, Western Union Telegraph Co., Philadelphia, Pa.
Heintz, C. A., junior engineer, Philadelphia Electric Co., Philadelphia, Pa.
Herman, R. H., electrical design engineer, Westinghouse Electric Corp., Lima, Ohio
Hicks, R. L., engineer, Toronto Hydro-Electric System, Toronto, Ont., Canada
Izzo, A., substation design engineer, West Penn Power Co., Pittsburgh, Pa.
Johnson, E. F., staff member, Sandia Corporation, Albuquerque, N. Mex.
Johnson, E. W., professor & assistant dean, Institute of Technology, University of Minnesota, Minneapolis, Minn.
Kamoroff, D., supervising electrical engineer, U. S. Army Ordnance Corps, Aberdeen Proving Ground, Md.
Kaupp, F. R., manager, Kaupp Electric Co., Merritton, Ont., Canada
Kimball, R. L., system analysis & development engineer, Gibbs & Hill, Inc., New York, N. Y.
Lange, J. E., operating engineer, Duquesne Light Co., Pittsburgh, Pa.
Leonard, S. C., measurements supervisor, General Electric Co., Pittsfield, Mass.
Lindell, S. I., chief engineer, S&C Electric Co., Chicago, Ill.
Maskiell, F. H., design engineer, Pennsylvania Transformer Co., Canonsburg, Pa.
Mawson, T. H., engineer, Southern Services, Inc., Birmingham, Ala.
McClellan, C. Y., system planning engineer, City Public Service Board, San Antonio, Tex.
Mitchell, J. D., Jr., southeastern regional engineer, Westinghouse Electric Corp., Chamblee, Ga.
Oxaal, A., circuit engineer, The North Electric Mfg. Co., Galion, Ohio
Rittenhouse, S. A., engineer, Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Sauer, T. H., consulting electrical engineer, 1425 S. Central Ave., Glendale, Calif.
Seelhoff, M. R., chief test equipment engineer, Redmond Co., Inc., Owosso, Mich.
Sullivan, J. B., distribution sales manager, Pennsylvania Transformer Co., Canonsburg, Pa.
Swarm, H. M., assistant professor, electrical engg. dept., University of Washington, Seattle, Wash.
Vasquez, A., vice-pres. & general manager, U. S. Relay Co., Los Angeles, Calif.
Wascheck, G., member of technical staff, Bell Telephone Laboratories, New York, N. Y.
Wendel, D. D., transmission & distribution manager, Alabama Power Co., Birmingham, Ala.
Willey, H. C., chief electrical engineer, The International Nickel Co., Inc., Huntington, W. Va.
Williams, C. H., principal electrical engineer, The Hawaiian Electric Co., Ltd., Honolulu, T. H.

47 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before April 25, 1954, or June 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

De Silva, S. R., Gal Oya Development Board, Amparai, Ceylon
El-Dajani, W., Homs & Hama Electric Co., Hama, Syria
Hassan, M., Pakistan Ordnance Factories, Wah Cantt, Pakistan
Leach, E. A., Sangamo Electric Company, Springfield, Ill.
Maynz, T., American Viscose Corp., Philadelphia, Pa.
Seeley, S. W., RCA Laboratories, New York, N. Y.
Sherwin, E. T., American Linen Supply Companies (International), Chicago, Ill.
Strouse, B. H., Consulting Engineer, 630 Guarantee Trust Bldg., Atlantic City, N. J.
Warren, J. R., Canadian General Electric Company, Ltd., Toronto, Ont., Canada

9 to grade of Member

OF CURRENT INTEREST

Radar Stations to Track Guided Missiles Are Linked by Polyethylene Coaxial Cable

Radar stations to track new supersonic guided missiles across the world's longest proving ground are linked under the Atlantic Ocean by a slender coaxial cable insulated with Bakelite polyethylene. When completed, the new U. S. Air Force Missile Test Center at Cape Canaveral, Fla., will have a test range extending more than 1,000 miles southeast into the Caribbean, and this can be extended to 5,000 miles if necessary.

Developed by Bell Telephone Laboratories, Inc., the new cable-insulating compound is based on a high-molecular-weight polyethylene resin produced by Bakelite Company, a Division of Union Carbide and Carbon Corporation. Strung on the ocean floor at depths of more than 2 miles, this coaxial telephone cable will carry high-frequency messages from island-based observation stations along the range back to a central control post in Florida. Information sent by radio from rocket missiles traveling at speeds up to 3,000 mph will be picked up by each station as the missile passes. To preserve its secrecy, telemetered information is transmitted to the base in Florida via the new submarine telephone cable together with other data recorded by the radar tracking equipment.

In the stubby rocket's hull, instruments register altitude, speed, direction, fuel consumption, skin temperature, and other data. This information is broadcast as a continuous signal to telemetering equipment antennas set up at the island observation stations. Similar data on the missile's speed, direction, and altitude also are tape recorded in code from the radar tracking equipment. Subsequently all information is sent back to Central Control at the Florida base over the submarine cable.

Due to the resistance of polyethylene to attack by salt water the relatively thin cable is protected from the tons of ocean under which it is buried. The exceptional electrical characteristics of polyethylene also provide lower attenuation than other insulating materials for the high-frequency signals used. Lower electrical loss adds to the unique combination of properties held by polyethylene such as its light weight, its toughness, and its resistance to abrasion, to corrosion by sea water, and to the action of acids, alkalies, oxidizing agents, and most other chemicals.

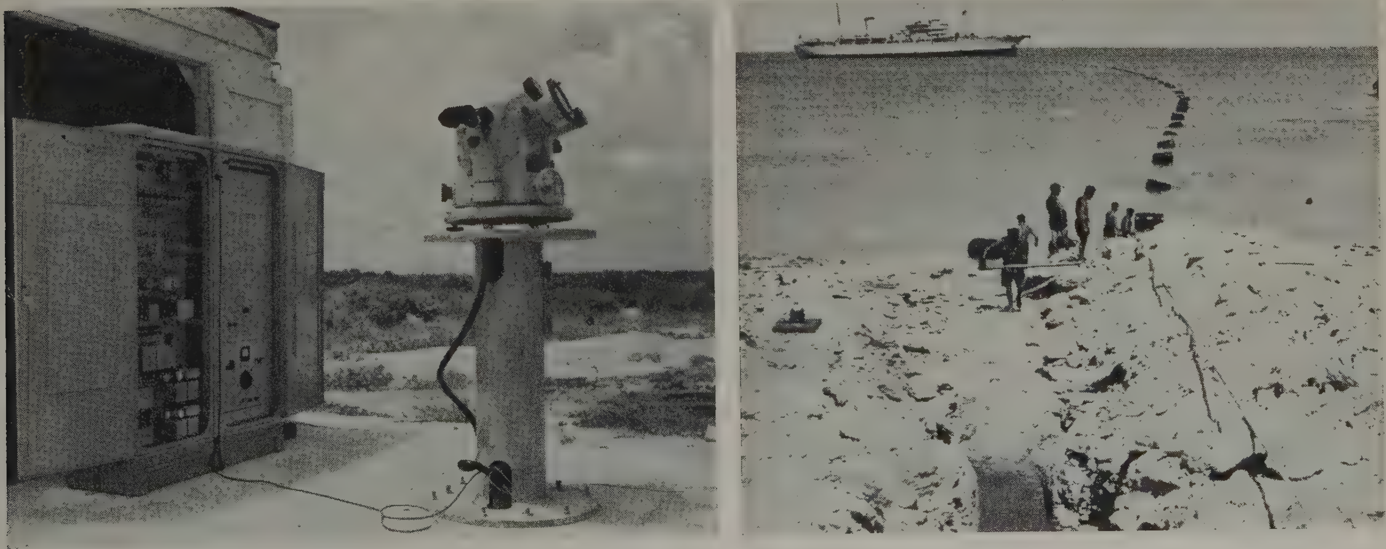
The cable is laid in almost a straight line on a bearing of 127° starting from the launching area at Cape Canaveral on the Florida coast and threading its way among the thousands of islands in the British West Indies or Bahamas down past Puerto Rico. When a rocket-powered missile is launched from the pad at Cape Canaveral (as shown on the cover), it is headed out to sea following the path of the cable on the ocean floor. Spaced at irregular distances, between 150 and 300 miles apart, are radar-equipped observation stations on Grand Bahama, Eleuthera, San Salvador, Mayaguana, and Grand Turk Islands, and stations in the Dominican Republic and Puerto Rico. The first observation station is at Point Jupiter, 20 miles north of West Palm Beach, Fla.

At speeds that reach as high as 3,000 mph, guided missiles can cover the whole course in less than an hour. Moving across the sky at supersonic speed, the missile takes only a few minutes to go from an observation station's northwest horizon diagonally across to the other horizon. Tracking and recording flight data on the fast disappearing missile require careful co-ordination and exact timing as they pass quickly from one observation point to another. Split-second co-ordination and timing are maintained via the submarine telephone cable. The in-flight safety control officer at each station is alerted when the missile enters his area and responsibility for the missile passes into his hands. These officers can destroy the missile or shut off its fuel if it changes course suddenly or begins to drop near a populated area. When the missile plunges into the sea at the end of its run, the nearest station attempts to recover it with crash boats.

Electronic instruments at the stations continuously record data on tape-recording machines. Cameras which photograph the missile in flight simultaneously record its elevation, direction, and timing. Plotting boards record the radar tracking with moving pens that trace out on maps the line of flight and elevation. The complex and voluminous data obtained from a wide variety of instruments are transmitted later through the submarine telephone cable to Central Control, where they are assembled to form a complete and detailed picture of the flight.

Before a missile is launched for its test flight, loudspeaker-equipped planes from each station warn ships and other aircraft from the range. Because the tests are too costly to risk instrument failure, each station warms up electronic equipment and tests it before the all clear is passed along to the firing-control officer. Three miles from the launching pad is the Central Control where the intricate communications network terminates and all information is gathered.

The new missile range permits longer-



(Left) Electronic and optical tracking instruments at observation stations constantly watch while the missile is in flight. Telemetering equipment picks up information on altitude, speed, fuel consumption, and other data which is recorded and sent to Central Control over coaxial cable. (Right) Polyethylene-insulated coaxial cable is laid on ocean floor to link radar stations tracking the supersonic guided missiles range test flights for the increasingly important guided missile program. The Air Force Missile Test Center, one of the nine research, development, and testing centers of the Air Research and Development Command, provides a service to contractors for the testing of guided missiles, drones, controlled targets, components, and allied equipment. With the new test range, valuable information on long-range pilotless flight will be gathered for use in improving these formidable guided missiles.

Computer Memory Improvement Program Has Initiated Design of New Storage Tube

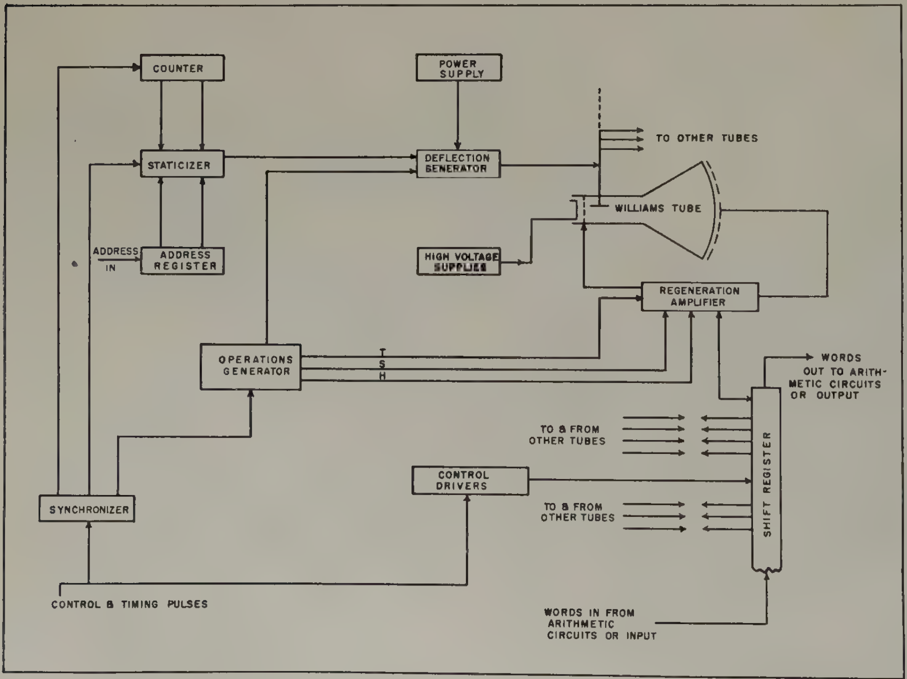
Experience with Williams electrostatic memory techniques at the National Bureau of Standards (NBS) has yielded increased reliability of this memory system in SEAC (National Bureau of Standards Eastern Automatic Computer). In a computer memory improvement program, the NBS electronic computer laboratory initiated the design of a new storage tube adapted specifically to the needs of the Williams system as well as the application of circuit techniques that overcome difficulties presented by the original system.

Named for its originator, Professor W. C. Williams of the University of Manchester (England), the Williams electrostatic storage technique uses ordinary cathode-ray tubes of the oscilloscope type to store information in electrical coded-pulse form. The pulses are stored as "dots" or "dashes" (corresponding to the binary "zero" and "one") at a large number of positions on the face of the tube, in a regular pattern known as a "raster." When information is to be stored, the tube's electron beam is directed to various positions on the raster and remains at each position for either a very short interval (a fraction of a microsecond) or a longer interval (several microseconds), providing two configurations (dot or dash) of electrostatic charge which is restored automatically to full strength at regular intervals. When the information stored at a particular location is wanted, it can be obtained very rapidly by deflecting the tube's electron beam to the point of interest on the face of the tube. The output signal is coupled capacitively from the phosphor surface inside the tube to a metal screen on the outside face, and is amplified and recognized through suitable circuitry as a dot or a dash.

The memory development program has involved various aspects of the design, test, and evaluation of electrostatic systems. The study has proceeded along five major lines: (1) investigations to develop the theory of Williams-type storage, (2) development of circuitry for a parallel memory system, (3) development of testing methods and equipment to determine the suitability of cathode-ray tubes for storage purposes, (4) co-operation with other groups interested in electrostatic memories to obtain improved storage tubes, and (5) devising of methods to overcome the deficiencies of standard cathode-ray tubes.

Attempts at analysis of electrostatic storage indicate that rather complicated phenomena occur within the cathode-ray tube. As developed at NBS, the theory of electrostatic storage is based on the original propositions advanced by Profession Williams, but it includes modifications by other workers in the field and is supplemented by information obtained from the Bureau memory improvement program. Until recently, this complex theory considered the mechanism of storage as being analogous to the operation of a space-charge-limited diode. The cathode in this case is an electron-bombarded spot on the phosphor screen that emits secondary electrons, and the anode is the aquadag coating on the inside of the cathode-ray tube. The NBS contribution, called the triode theory, considers that an added lower-potential region surrounding the spot is equivalent to a coplanar grid. The action then becomes somewhat analogous to a 3-element tube. While the NBS theory is still tentative, it does explain certain important effects caused by changes in the potential of the area adjacent to the region of primary electron bombardment.

Demonstration pattern of dots and dashes on the face of a cathode-ray tube in SEAC's Williams storage system. (Actual Williams tubes have a copper screen across the face; to get a clear picture of the dots and dashes, this picture was taken on a monitor tube connected in parallel with the screened Williams tube)



Block system of the Williams electrostatic memory that has been added to SEAC

During the early days of Williams-type storage in this country, it was thought that such storage could be accomplished using standard commercially available cathode-ray tubes. However, because of the unsuitability of most of the tubes for this application, it was necessary to discard about four out of every five from production lots.

Two lines of attack on the problem of improved tubes have been emphasized in most electronic computer laboratories. The first approach has been an effort to minimize the limitations of available tubes; the second has sought to obtain an improved tube. Both approaches recently have yielded satisfactory results.

One of the major tube problems has been the presence of minute areas on the phosphor surface which do not store information. During operation of the memory these "blemishes" must be avoided, or the tube discarded. It is difficult to avoid these nonstoring spots when many tubes are operated in parallel: if the raster in one tube is shifted to miss a blemish, the raster in another tube may coincide with one. Computer operation then becomes unreliable, for the memory gives false information.

Test circuitry has been developed at the NBS laboratory that will locate the blemishes on the face of a tube and measure the degree to which these bad spots will not store. Use of this equipment determines a tube's suitability for SEAC's memory. Techniques for removing blemishes have been refined to the extent that now only 20 per cent of new 3-inch-diameter tubes are rejected for this reason, compared to the former rate of 80 per cent.

A second major difficulty encountered in Williams storage is the obliteration of the stored charge at one spot by the splash of the secondary electrons emitted from the neighboring spots during read-write operations. The number of interrogations of near-by spots which may be made before regeneration is required is called "read-around-ratio." A low read-around-ratio may be improved either by the use of operating methods which place serious limitations on the use of the memory or by improving the intrinsic properties of the tube in this respect.

The splash effect is mostly a function of gun design. To mitigate this difficulty, manufacturers were approached regarding improved designs, and several trial tubes were ordered, based on NBS design suggestions. These were tested at NBS and other computer laboratories. The results were so encouraging that a conference was called at NBS for computer specialists from other government agencies and government associated activities. This led to an agreement on specifications for a standard computer tube, and small-scale production of this tube has begun.

Specially Cast Plastic Scintillators Developed by Argonne Laboratory

Scientists at the Argonne National Laboratory have found that certain plastic materials may be used to advantage in scintillation counters, overcoming various limitations encountered with other materials. Through experimental work, reliable methods have been developed for producing efficient plastic scintillators by means of a polymerization casting and fabricating process. One of the most effective plastic materials thus far tested is polyvinyltoluene, a closely related methyl substitute for regular commercial styrene.

Until recently, the use of scintillation counters was limited by the difficulty of obtaining single large crystals of sufficient size to provide the desired sensitivity.

As a result of the work conducted at Argonne, and reported in *Modern Plastics*, the laboratory is able now to produce transparent plastic scintillators comparable in performance to single crystals. One material in particular—a solid solution of terphenyl and diphenylstilbene in polyvinyltoluene—has a very high efficiency and may be produced in large volumes as easily as commercial polystyrene.

Since high transparency is required in the scintillators, oxidation and consequent yellowing of the plastic must be avoided. For this purpose the Argonne scientists have developed methods of purifying the monomer and of achieving carefully controlled polymerization in the absence of oxygen and without the need for peroxide-type catalysts.

The first step in the production of plastic scintillators consists of purification of the vinyltoluene monomer. Next, small concentrations of one or more organic fluorescent materials, such as terphenyl and diphenylstilbene, are dissolved in the liquid monomer.

The monomer solution is transferred then to Pyrex glass vials of the desired shape and size and the space above the monomer evacuated, after which the vial is sealed and the polymerization process is carried out in a controlled temperature bath.

For long rods up to 3 inches in diameter, polymerization is initiated at from 100 to 120 C, then raised to around 140 C after 1 or 2 days. After reaching the peak curing temperatures, where the material may be held for a week or longer, temperature is reduced gradually to avoid forming voids in the castings. Following the cooling period, the casting is allowed to remain for 24 hours just below the softening point for annealing. The glass tubes containing each casting then are plunged into water at the same temperature and the water allowed to cool down gradually, causing the glass and plastic to shrink apart. The glass is removed and the completed plastic casting then is machined to final shape and size. It is believed that, if necessary, the plastic scintillators could be cast to their ultimate dimensions.

Intercommunication System Has Memory Circuit, Right-of-Way

A new dial-type intercommunicating telephone system that has a number of unique new features, including a memory circuit and a device that allows key executives to cut in to a busy line with urgent messages, has been announced by the Sound Equipment Division of the Stromberg-Carlson Company.

This new private telephone system, called Dial-*X*, also provides many other facilities, such as direct connection with a paging or sound system, simple and easy calling of telephone conferences, and unlimited simultaneous service of the entire system.

The Dial-*X* memory circuit makes it unnecessary for any user of the system to repeat the dialing of a line that is busy. The system remembers the call, and completes it the instant the busy line becomes available.

The executive right-of-way feature gives key executives facilities for pre-empting any line in the system, even though it may be busy when the call is made. The executive simply dials the numbers he wants, and presses a button. That sounds a warning signal on the busy line, and then makes the connection, allowing the executive to put urgent messages through at any time.

With the Dial-*X* system any desired number of people can confer simply by dialing a conference call. Only those who should take part in the conference, and no others, are on the one line. The system also can be connected with a regular paging or sound sys-

Future Meetings of Other Societies

American Institute of Chemical Engineers. National Meeting. May 16–19, 1954, Kimball Hotel, Springfield, Mass.

American Society of Tool Engineers. 10th Biennial Industrial Exposition. April 26–30, 1954, Philadelphia Convention Center, Philadelphia, Pa.

American Welding Society. National Spring Meeting. May 4–7, 1954, Hotel Statler, Buffalo, N. Y.

Association of Iron and Steel Engineers. Spring Conference. May 3–5, 1954, Belleview-Stratford Hotel, Philadelphia, Pa.

Basic Materials Conference and Exposition. May 17–20, 1954, International Amphitheatre, Chicago, Ill.

Conference for Protective Relay Engineers. 7th Annual Conference. April 26–28, 1954, Agricultural and Mechanical College of Texas, College Station, Tex.

Conference on Applications of Computing Machines. April 13–14, 1954, Case Institute of Technology, Cleveland, Ohio

Conference on Frequency Control. 8th Annual Symposium. April 12–14, 1954, Berkeley-Carteret Hotel, Asbury Park, N. J.

Conference on Instrumentation in Water, Sewage, and Industrial Waste Treatment. April 22, 1954, Manhattan College, New York, N. Y.

Edison Electric Institute. 20th Annual Sales Conference. April 5–8, 1954, Edgewater Beach Hotel, Chicago, Ill.

Institute of Physics. Conference on the Physics of Particle Size Analysis. April 6–9, 1954, University of Nottingham, Nottingham, England

Institute of Radio Engineers—Polytechnic Institute of Brooklyn. Symposium on Information Networks. April 12–14, 1954, Engineering Societies Building, New York, N. Y.

Instrumentation Conference. 2d Annual Conference. April 8–9, 1954, Louisiana Polytechnic Institute, Ruston, La.

Metal Powder Association. 10th Annual Meeting and Metal Powder Show. April 26–28, 1954, Drake Hotel, Chicago, Ill.

National Fire Protection Association. 58th Annual Meeting. May 17–21, 1954, Hotel Statler, Washington, D. C.

National Fluid Power Association. 1st Annual Meeting. April 5–7, 1954, Edgewater Gulf Hotel, Edgewater Park, Miss.

Northwest Electric Light and Power Association. Engineering and Operations Sections. April 15–17, 1954, Olympic Hotel, Seattle, Wash.

Operations Research Society. 2d Annual Meeting. May 21–22, 1954, Edgewater Beach Hotel, Chicago, Ill.

Pacific Coast Electrical Association. Annual Convention. May 19–21, 1954, Hotel Del Coronado, Coronado, Calif.

Pennsylvania Society of Professional Engineers. Annual State Convention. May 7–8, 1954, Bedford Springs Hotel, Bedford, Pa.

Rice Institute Exposition of Engineering, Science, and Arts. 14th Biennial Review. April 2–3, 1954, Rice Institute, Houston, Tex.

Royal Netherlands International Industries Fair. 62d International Trade Fair. March 30–April 8, 1954, Utrecht, Netherlands

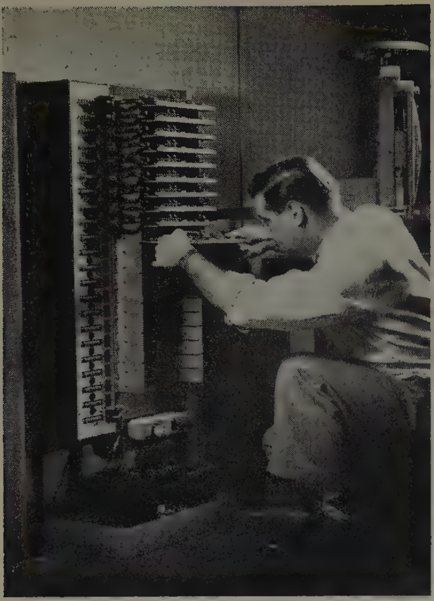
Society of Automotive Engineers. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display. April 12–15, 1954, Hotel Statler, New York, N. Y.

Society of Naval Architects and Marine Engineers. Spring Meeting. May 17–18, 1954, Olympic Hotel, Seattle, Wash.

Society of the Plastics Industry (Canada). 12th Annual Conference. April 5–6, 1954, Mount Royal Hotel, Montreal, Que., Canada

Stanford Research Institute—U. S. Air Force. Symposium on the Automatic Production of Electronic Equipment. April 19–20, 1954, Fairmont Hotel, San Francisco, Calif.

The American Society of Mechanical Engineers. Spring Meeting. April 18–20, 1954, Baltimore, Md.



Dial-X switchboard, showing how additional lines can be added by sliding selectors in place and plugging them in

tem, so that anyone with a Dial-*X* phone on his desk can broadcast a message, or make an announcement, simply by dialing the paging line.

Dial-*X* switchboards provide complete protection against eavesdropping, for, when a line is in use, all other lines are locked out, except when the conference call or the "executive right-of-way" are used. Since there are no shared circuits in the switchboard, all the phones in the system can be used at once. Peak calling periods do not cause traffic tieups in the switchboard, and the only times a busy signal is sounded is when the line dialed is actually in use.

The Dial-*X* system has its own power supply, ready to plug in to any 110-volt 60-cycle line.

Symposium on Semiconductors Held in Washington, D. C.

Definite trends to operation of transistors at higher frequencies, higher temperatures, increased power, lower noise levels, and longer operating life were indicated at an all-day symposium on semiconductor research at the Naval Research Laboratory in Washington, D.C., on February 11, 1954. As a feature of the meeting, William Shockley, Bell Telephone Laboratories, delivered the first Thomas A. Edison Lecture, sponsored by the Naval Research Laboratory Branch of the Scientific Research Society of America, on the topic, "Present and Future of Semiconductor Research."

Improved characteristics are being obtained by continuing research on new and improved materials, geometry of the transistor itself, as well as circuit designs, according to the speakers at the meeting.

An experimental FM transmitter and receiver operating at 250 mc, and using multielectrode junction transistors, were demonstrated for the first time by R.L. Wallace, Bell Telephone Laboratories. The transmitter and microphone were small enough to be clipped to Mr. Wallace's shirt collar and the receiver was completely transistorized, except for the power amplifier.

New electroetching and electrodepositing techniques, as used in the surface-barrier transistor, which is not a multielectrode type, are permitting production of transistors with operating frequencies in the order of 60 mc, according to W. E. Bradley of the Philco Corporation. Mr. Bradley revealed that Philco is experimenting with electrodeposited zinc, tin, and lead on n-type germanium as new surface-barrier materials.

Nonsaturating transistor flip-flop circuits, designed for operation at 1 mc but capable of operation at frequencies up to 7 mc, have been developed, on an experimental basis, by A. W. Carlson, Air Force Cambridge Research Center. These circuits make use of nonsaturating load lines and have been used by Mr. Carlson and others in the design of high-speed switching circuits, as used for digital computers, among other applications.

As an indication of a trend toward higher power transistors, C. L. Rouault, General Electric, reported the development of experimental 50-watt transistors, with current-carrying capacities up to 1 ampere.

Operating temperatures up to 250 C are possible through the use of semiconducting materials other than germanium, notably silicon, according to E. W. Herold, Radio Corporation of America. Research is continuing on the combination of nonelemental materials to form semiconductors, according to R. G. Breckenridge, Office of Naval Research. These include indium-antimony, aluminum-antimony, cadmium-sulfide, and lead-sulfide. Current work on the physical properties of silicon and germanium was summarized by Esther M. Conwell of Sylvania. Research in progress on noise in semiconductors, rectifiers, and transistors, was reported by R. L. Petritz, Naval Ordnance Laboratory.

In reviewing the current state of knowledge of semiconductors, Dr. Shockley implied the need for continuing investigation of the basic physical properties of transistors. As examples, he pointed out the recent discoveries of the "charge-carrier traps" and negative "resistance" phenomena of transistors at high electric fields—in the millimeter wavelength region and below.

Electronic Office Equipment Demonstrated Over TV System

Subject matter and means of presentation were linked at a February conference of the American Management Association at the Astor Hotel, New York, N. Y., when the latest models of electronic office equipment were demonstrated to a large audience over a closed-circuit television system.

Nine exhibitions of common-language machines had their equipments in operation in the 8th floor ballroom of the hotel. Three television cameras picked up each in turn from different angles as the demonstrator explained his equipment's functioning. Picture and voice were transmitted over a closed circuit to the main-floor ballroom where 1,700 persons saw the pictures projected by a theater-television outfit on a large screen.

A question-and-answer period followed the nine remote demonstrations. Questions on cards were read into a 2-way communication circuit between the two ballrooms and the questioned demonstrator answered from upstairs. The advantages were obvious as a demonstrator could answer a question by showing how a machine performed a certain function. Thus a large group was enabled to benefit by seeing close-ups which otherwise only a relatively few persons could see at one time.

Human Engineering Course to Be Held in Connecticut

A 5-day course dealing with the design of equipment, products, and work stations with emphasis on human limitations and capacities will be held the week of May 10, 1954, in Stamford, Conn.

Engineers, designers, product planners, safety specialists, and members of related professions are becoming increasingly aware of the importance of a basic knowledge of human engineering. Last year a 5-day institute was held to meet practical needs. This year's institute incorporates not only the suggestions of last year's participants but also the most recent experience of human engineering specialists.

Presentations offer new approaches to more intelligent product planning; safe, efficient operation; simplified selection, training, maintenance; increased user satisfaction. Specific subject matter includes: allocation of jobs to men and equipment; design of instruments, warning devices, handles, pedals, etc.; seating, panel design, other workplace aspects; control of lighting, air, noise, vibration.

Sessions are arranged to yield the advantages of both group instruction and individual attention by instructors. Consequently, enrollment will be limited. Lecture-discussions will be conducted for approximately 16 people and laboratory sections for approximately 4. The course emphasizes practical design problems. Laboratory sessions will apply the principles, facts, and methods presented in class meetings.

Deadline for enrollment is April 15, 1954. Further information about the course may be obtained from Dr. Bernard J. Covner, Director, Human Engineering Institute, Dunlap and Associates, Inc., 429 Atlantic Street, Stamford, Conn.

Information Networks Is Topic of International Symposium

Information Networks is the topic of the third of a series of annual international symposia to be held April 12–14, 1954, at the Engineering Societies Building, 33 West 39th Street, New York, N. Y.

The symposium will deal with network theory, particularly network synthesis as it is influenced by the newer concepts developed in information and general communication theory. In particular, the first part will concentrate upon the performance of networks and their design for specific types of information such as pulses, pulse modulation, statistical inputs, etc. The second part will concentrate upon the generalized network concepts and their application to computer and switching systems, neutron networks and optical systems. American and European authorities, who have made original contributions to the art, will participate.

The co-operation of the Institute of Radio Engineers (IRE) Professional Group On Circuit Theory and the cosponsorship of the Office of Naval Research, the Air Force Office of Scientific Research, and the Signal Corps permits this symposium to be held without admission charge or registration fee. "Proceedings of the Symposium on Information Networks" will be published by October 1954, at a cost of $4.00 per copy. A cloth bound edition also will be available at additional cost. Members of the IRE Professional Group on Circuit Theory may obtain a copy at a saving of $1.00. Orders for the "Proceedings," accompanied by check or money order, made out to Treasurer, Network Symposium, will be accepted in advance. Copies of the detailed program, hotel accommodation information, and registration forms are available on request. All correspondence should be addressed to: Polytechnic Institute of Brooklyn, Microwave Research Institute, 55 Johnson Street, Brooklyn 1, N. Y.

General Electric Produces World's Largest Light Bulb

The General Electric Company has developed and produced the world's largest and most impressive artificial light source A 75,000-watt incandescent lamp bulb, it is half again as large as the previous largest bulb. It was developed as a feature of General Electric's observance this year of the 75th birthday of Edison's electric light.

This giant among light bulbs was turned on officially for the first time on Edison's 107th birthday, at ceremonies in Rockefeller Center, N. Y. C., overlooking the skating rink. It will be displayed and lighted throughout the year at Light's Diamond Jubilee celebrations, and at conventions, shows, and fairs in all sections of the country.

The lamp was conceived, designed, and assembled by lamp development scientists and engineers at Nela Park, headquarters of General Electric's Lamp Division. Its glass bulb, largest every made, was hand blown by the Corning Glass Company, first producer of bulbs for Edison.

The lamp produces 2,400,000 lumens. To produce this amount of light would require 2,874 60-watt household bulbs, all burning simultaneously. This single light bulb uses enough electric energy to light 83 American homes as they normally are lighted today. Twenty-three of them could illuminate a major league baseball stadium according to modern standards.

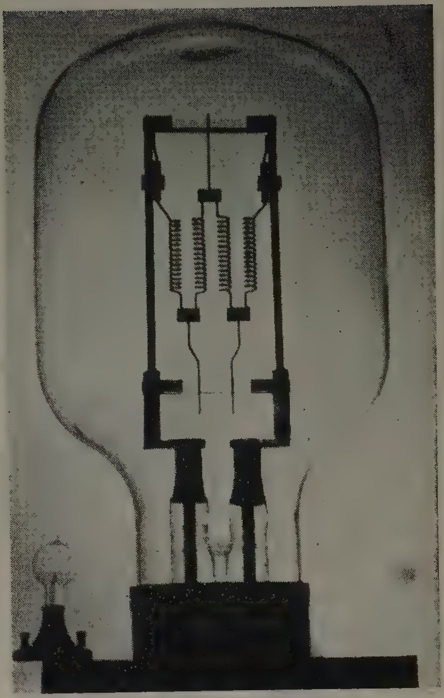
The lamp's filament alone weighs 2.7 pounds, which is enough tungsten to make the coiled-coil filaments for 67,500 60-watt lamps. The filament is made of a tungsten ingot, hammered to a diameter of 3/16 of an inch. It is 12½ feet long.

The filament was swaged at a General Electric wire factory in Cleveland, Ohio, and the mount, or framework which supports the filament, was assembled in General Electric's Lamp Development Laboratory at Nela Park, where the lamp was completed and turned on and tested for the first time.

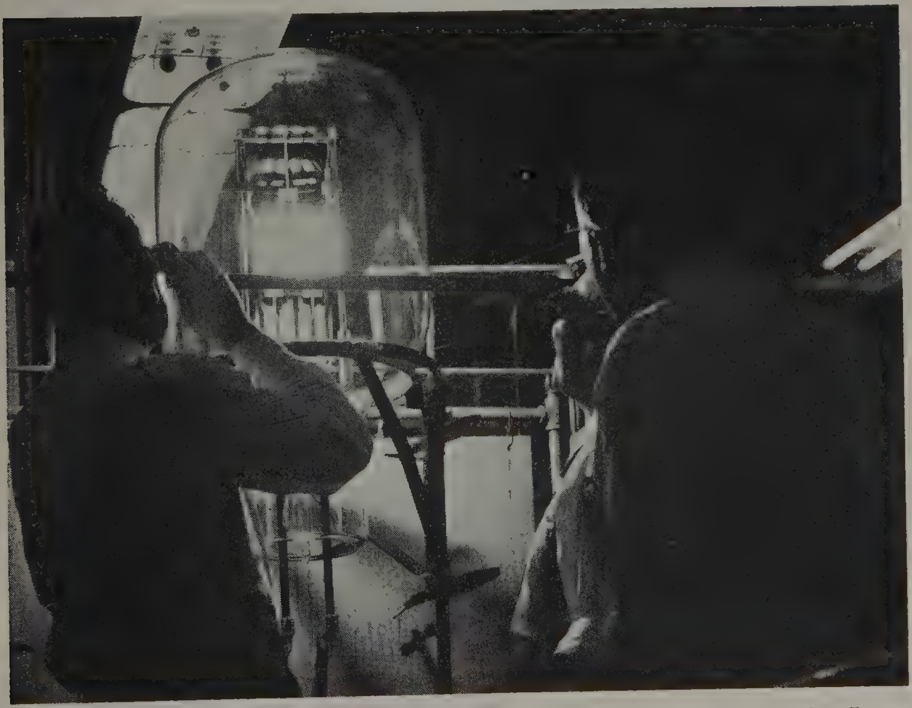
The huge lamp is so bright and hot that observers are advised not to look directly at it or stand close to it when it is burning at full brilliance.

The 75,000-watt bulb gives out 32 lumens per watt and is one of the most efficient incandescent light sources yet produced.

Three of the huge lamps will be on display throughout the year, one at Light's Diamond Jubilee celebrations, another in the Lighting Institute at Nela Park, and a third at exhibits, conventions, and fairs.



The world's largest light bulb, a 75,000-watt lamp, alongside a replica of Edison's first successful incandescent lamp



Original test lighting of 75,000-watt light bulb is shown in General Electric's Lamp Development Laboratory, Cleveland, Ohio, where it was designed and assembled. Development engineers were required to use heavy dark glasses to study the lamp's performance at close range

Aviation Electronics Development to Be Studied at Joint Meeting

"Aviation and Electronics Look Ahead" will be the theme of a joint meeting on aeronautics to be held by four scientific organizations at The Franklin Institute in Philadelphia, Pa., on April 22 and 23, 1954.

The sponsoring organizations are: the Radio Technical Commission for Aeronautics, The Franklin Institute Laboratories for Research and Development, the Philadelphia section of the Institute of the Aeronautical Sciences, and the Philadelphia chapter, Professional Group on Aeronautical and Navigational Electronics, The Institute of Radio Engineers.

The program will include discussions on a wide range of subjects in related fields, including air transportation, aircraft design, electronics development, and airport operations.

Among the speakers will be: Frederick M. Glass, director of aviation development, Port of New York Authority; Frank N. Piasecki, of Morton, Pa., chairman of the board, Piasecki Helicopter Corp.; Charles Froesch, of New York, vice-president for engineering, Eastern Air Lines; Graham Aldrich, of Washington, director of special projects, Air Transport Association; and Ralph H. McClarren, of Philadelphia, consulting engineer.

Technical papers will be presented on present and future trends of development in aviation and in aeronautical electronic devices to assist members in planning changes and modifications likely to be required in existing equipment and procedures for air navigation, communication, and traffic control.

The first day will be devoted to aircraft, airports, and air traffic potentials. New electronic devices and their applications will be discussed on the second day.

Luncheon will be served at The Franklin Institute on both days of the meeting. After a reception and buffet supper on the evening of the first day, a demonstration, "Destination Saturn," will be presented in the Fels Planetarium of The Franklin Institute by Dr. I. M. Levitt, director of the Planetarium.

Nonmembers of these organizations may attend the meetings.

Oak Ridge Announces Courses on Basic Isotope Techniques

The Special Training Division of the Oak Ridge Institute of Nuclear Studies will offer three basic isotope techniques courses during the summer months. Starting dates of the 4-week courses are in June, and on July 12, and August 9, 1954.

The laboratories, counting room, and lecture room of the Special Training Division recently have been remodeled and enlarged, and the institute's Technical Library soon will occupy new quarters recently added to the Training Building.

Additional information on the courses may be obtained from the Special Training Division of the institute, P. O. Box 117, Oak Ridge, Tenn.

Frequency Control Symposium to Be Held by Signal Corps

The Signal Corps Engineering Laboratories at Fort Monmouth announces the 8th annual Frequency Control Symposium, to be held in the Berkeley-Carteret Hotel, Asbury Park, N. J., on April 12–14, 1954.

The purpose of this annual conference is to promote a better understanding and wider dissemination of technical knowledge gained in the field of frequency regulation, and is open to all persons concerned with or interested in this phase of electronics. The results of these annual conferences often determine the course of future research and development within the laboratories.

The conference will feature guest speakers from many of the larger civilian laboratories, colleges, and utilities corporations, as well as leading scientists from all branches of military research centers. International coordination includes, among others, electronic engineers from Canada and England.

Included in the tentative discussion program are such topics as Quartz Synthesis, Properties of Crystalline Materials and Piezoelectric Vibrators, Aging Forum, Control Devices and Applications, and Circuits and Temperature Control System.

Additional information and reservations for the symposium can be obtained from the Frequency Control Branch, Squier Signal Laboratory, Fort Monmouth, N. J.

Universities Announce Programs for Summer Conferences

Preparations for the largest program of special professional courses and conferences in its history are being made for the summer of 1954 at the Massachusetts Institute of Technology (MIT). Plans have been announced for 34 special summer programs, a series of professional conferences and symposia, and more than 100 subjects from the institute's regular courses to be given during the coming summer. They will cover all fields of science and engineering represented at MIT.

The 34 special summer programs, which are 1- to 4-week courses in limited fields, are planned primarily for those with professional experience in industry, government, and education. In addition, a series of conferences and symposia will bring together for 1/2, 2, or 3 days, groups of specialists concerned with particular professional problems.

More than 100 subjects from the institute's regular professional courses will be given during the coming summer in two 6-week periods, June 14 to July 23 and July 26 to September 3.

Further details of MIT activities planned for the 1954 summer session may be obtained from the Summer Session Office, Room 7-103, MIT, Cambridge 39, Mass.

The University of Michigan, College of Engineering, has announced two intensive courses in automatic control. The first is scheduled for June 14 to 19, and the second for June 21 to 23. The courses are intended for engineers who find it necessary or who wish to obtain a basic understanding of the field, but who cannot spare more than a few days for this purpose. The aim of the courses is to make it easier to learn by a coherent presentation of the fundamentals of modern automatic control and by providing a comprehensive set of notes to serve as a framework for further study.

The courses are built around the principles and application of measurement, communication, and control. Course I will consist of the fundamentals in each of these fields and will include some fundamental work in nonlinear systems. Course II will take up applications of the fundamentals to more advanced problems. There will be 4 hours of lecture each morning and 3 hours of demonstration in the afternoon. Extensive use will be made of computing, instrumentation, and servo laboratories on the campus.

April 15, 1954, is the closing date for registration. Further information may be obtained by writing to Professor M. H. Nichols, Room 1523, East Engineering Building, University of Michigan, Ann Arbor, Mich.

Pennsylvania State University, in cooperation with industry, is offering summer seminars on the following subjects: Transistors, June 9 to June 18; Color Television, June 21 to July 2; Analogue Computers, June 21 to July 2; Electric Contacts, June 28 to July 2; and Electrostatic Precipitation, June 21 to June 25.

These courses are designed primarily to disseminate the recent technological advances in these various fields. Further information may be obtained from R. L. Riddle, Chairman, Short Course Committee, Pennsylvania State University, State College, Pa.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ASTM STANDARDS ON TEXTILE MATERIALS. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 677 pages, 9 by 6 inches, paper. $5.25. Test methods, definitions, specifications, tolerances, and recommended practices for all textile materials—asbestos, bast and leaf fibers, cotton, glass textiles, rayon and acetate, silk, wool, and felt. The standards also cover fabrics, yarns, threads, and cordage; while test methods cover testing machines, humidity, and interlaboratory testing. There are also a number of tentative and proposed tests.

ADVANCES IN ELECTRONICS, VOLUME V. Edited by L. Marton. Academic Press, Inc., 125 East 23d Street, New York 10, N. Y., 1953. 420 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $9.50. Continuing the series, the present volume presents some 50 articles on specialized topics grouped under the following headings: performance of detectors for visible and infrared radiation; beta-ray spectrometers; solid-state luminescence; thorium oxide and electronics; modern vacuum pumps in electronics manufacturing; steady-state theory of the magnetron; color television; junction transistor applications. Cumulative author and subject indexes covering the first five volumes are included.

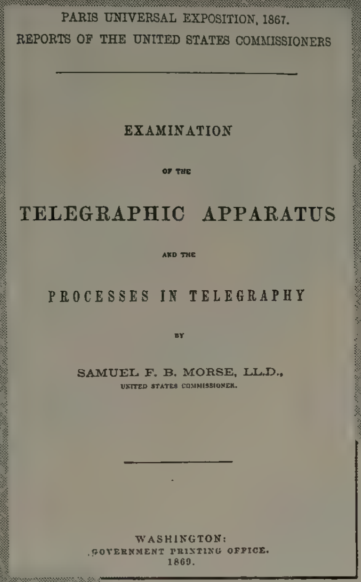
ANNUAL REVIEW OF NUCLEAR SCIENCE, VOLUME III. Edited by James G. Beckerley. Annual Reviews, Inc., Stanford, Calif., 1953. 412 pages, 9 by $6^{1}/_{4}$ inches, bound. $7. The 15 papers contained in the broadened scope of this third volume cover a considerable range of topics, including the following: reactions of mesons with other particles, neutron optics, photographic emulsions, separation techniques used in radiochemistry, isotope effects in chemical reactions, radiation dosimetry and protection, practical aspects of radiation injury, and vertebrate and cellular radiobiology. Essentially a literature survey with extensive reference lists.

ATOMS, MEN AND GOD. By Paul E. Sabine. Philosophical Library, 15 East 40th Street, New York 16, N. Y., 1953. 226 pages, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, bound. $3.75. In a succession of essay-like chapters the author, a research physicist, makes a thoughtful effort to effect a synthesis of the fundamental concepts of modern science and psychology with the intellectual content of Protestant religious faith.

BESSEL FUNCTIONS AND FORMULAE. Compiled by W. G. Bickley. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., 1953. 12 pages, 11 by $8^{1}/_{2}$ inches, paper. 75¢. A reprint of the section on "Functions and Formulae" from the British Association Mathematical Tables, volume X, Bessel Functions, part II; intended to provide, in an easily handled form, these fundamental mathematical tools.

DIMENSIONAL METHODS AND THEIR APPLICATIONS. By C. M. Focken. Edward Arnold and Company, London, England (distributed in the United States by St. Martin's Press, Inc., 103 Park Avenue, New York 17, N. Y.), 1953. 224 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $6. A critical survey of the subject of dimensions and the related study of units, written for the engineer and physicist with the intent to show the practical advantages of the use of dimensional methods. Opening chapters offering an elementary treatment and fundamentals are followed by a discussion of various physical magnitudes—spatial, thermal, and electrical. The two concluding chapters cover physical and engineering applications, the last chiefly concerned with model design.

DIPOLE MOMENTS. By R. J. W. Le Fèvre. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., third edition, 1953. 140 pages, $6^{3}/_{4}$ by $4^{1}/_{4}$ inches, bound. $2. A manual intended to aid the research worker in measuring and interpreting dipole moments, covering basic theory of dielectric polarization, practical measurement procedures, solvent effects, and the relation between dipole moments and molecular structure.



PARIS UNIVERSAL EXPOSITION, 1867.
REPORTS OF THE UNITED STATES COMMISSIONERS

EXAMINATION
OF THE
TELEGRAPHIC APPARATUS
AND THE
PROCESSES IN TELEGRAPHY
BY
SAMUEL F. B. MORSE, LL.D.,
UNITED STATES COMMISSIONER.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1869.

KERITE'S
100th Anniversary
1854—1954

Read what Professor B. Silliman of Yale University reported on the Kerite insulation exhibited at the Paris Universal Exposition of 1867.

TELEGRAPHIC APPARATUS, ETC.

DAY'S KERITE INSULATOR.

The kerite compounds of Austin Goodyear Day, mentioned in the following memoir, were honored by two medals and an honorable mention by the jury of the Exposition Universelle, to whom the subject was referred. These awards covered other products than the electrical cables and insulators which are the special object of the descriptive memoir.

NOTE UPON INSULATION AND KERITE, BY PROFESSOR SILLIMAN.

The exhibition of the kerite, this product of the persevering labors and experiments of Mr. Day for so many years, furnishes an example of the not infrequent inappreciation, or rather overlooking, of an invaluable discovery, when modestly presented, as in this case, among the more showy articles by which it was surrounded.

True, it received honorable mention as "artificial India-rubber," and a bronze medal for its very limited application to "India-rubber cases;" but its superlative value as a substitute in insulation for India-rubber and gutta-percha was not, for it could scarcely be, appreciated, presented as it was simply in one of its more ordinary applications; so that heedless neglect is not charged upon the jury, but it is mentioned rather as an example of the existence of an unnoticed quality in an apparently trifling discovery, necessarily latent to superficial inquiry; a quality which is destined in this case to have a most important bearing upon submarine and subterranean telegraphy.

The kerite, in its condition simply as artifi ssed under

The value and service life of a product can be no greater than the integrity and craftsmanship of its maker.

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3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston

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ROTATING THERMOCOUPLE and STRAIN GAGE CIRCUITS
ROTATING JOINTS • DYNAMOTORS

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INDUSTRIAL NOTES ....

General Electric News. The General Electric Company has signed a patent license agreement with Columbia Broadcasting System, Inc. (CBS), granting General Electric the right to manufacture and sell color television apparatus developed by CBS. Included in the CBS-developed equipment to be produced by General Electric are the single-tube "Chromacoder" color television camera and the "Chromododer," introduced last October and now in use in regular CBS television color broadcasts.

In preparation for the distribution of General Electric color television receivers, a division in responsibility for television sales has been announced. Paul H. Leslie has been appointed sales manager, monochrome television receivers; and Joseph F. Effinger, sales manager, color television receivers.

Boyette Edwards, Jr., has been named supervisor of industrial engineering for the Phenolic Products Plant of the General Electric chemical materials department. Mr. Edwards will continue to make his headquarters in Pittsfield, Mass.

New Raytheon Research Laboratory. Tentative plans for the construction of a large electronics engineering and research laboratory in Wayland, Mass., have been announced by Raytheon Manufacturing Company, Waltham, Mass. Raytheon conducts an extensive research and engineering program for the design and testing of advanced electronic equipment, both for governmental and commercial usage. For some time it has been considering a gradual consolidation of these into a single location, instead of conducting them in many scattered areas, as is now the case.

Change of Name. The former Micromax Company, of Brooklyn, N. Y., has changed its name to Computer Instruments Company in order to describe the nature of its expanding line of products. The manufacturing plant of the company will remain at 1964 Utica Avenue, Brooklyn, and facilities will be expanded.

BullDog Names Sales Manager. Gordon P. Bowman has been appointed district manager of the Cincinnati, Ohio, sales office of the BullDog Electric Products Company. Mr. Bowman is returning to Bulldog after being recalled to active duty for a 2-year tour of duty in the Korean area.

New Sales Office for NRC. The National Research Corporation has opened a sales office in Cleveland, Ohio, and has appointed George A. Goetz as their representative. His new office is at 4205 Chester Avenue, Cleveland 3, Ohio.

Professor Mann Named to Consulting Staff. The National Pneumatic Company, Inc., and Holtzer-Cabot Divisions, Boston, Mass., have announced the appointment of Professor Robert W. Mann to the consulting staff of the company's engineering department. Professor Mann is assistant professor of mechanical engineering and supervisor of the Design Division of the Dynamic Analysis and Control Laboratory at the Massachusetts Institute of Technology.

Change of Address. The American Society of Refrigerating Engineers announces that on and after March 1, 1954, its headquarters office will be located at 234 Fifth Avenue, New York 1, N. Y. The change was due to the building owner's desire to use the entire building for his own personnel.

Annual Safety Convention. New York's annual safety convention and exposition will be held in the Hotel Statler, April 5 through April 9. Among the meetings will be special sessions on aviation, commercial vehicles, safety among government employees, public utilities, hospitals, industrial nursing, building management, hotels, maritime and longshore operations, petroleum, and fire protection.

Du Mont Changes. As a result of increased demands for television broadcast equipment, Allen B. Du Mont Laboratories, Inc., has created a new television transmitter department which greatly will enlarge production, sales, and distribution activities of the company's former Television Transmitter Division. The transmitter is an operating arm of Du Mont's new Communication Products Division. Formation of the new transmitter department stems from two factors: the recent tremendous growth of Du Mont's broadcast equipment activities; and the development over several years of new Du Mont broadcast products. James B. Tharpe will head the television transmitter department as national sales manager. Named to aid Mr. Tharpe in the new departmental setup are Charles E. Spicer, sales operations manager; Lewis C. Radford, Eastern District manager; Herb Bloomberg, Central District manager; Robert J. Myers, Western District manager; and Thomas B. Moseley, Southern District manager.

Fred M. Link has been appointed director of operations for the company's newly formed mobile communications department. The mobile communications department is an operating arm of the Communication Products Division.

NEW PRODUCTS ••

Rectifier-Type Welder. A new 400-ampere d-c rectifier-type welder with a 60-per-cent duty cycle has been announced

(*Continued on page 22A*)

NEW Square D Size 4 Starter

Feature-packed!

"Hook-on" base design saves installation time and money

Special sintered metal contacts last longer

High arc-interrupting capacity with "magnetic yoke" arc chamber

Coil and contacts removable from front without disturbing power wiring

Up to 8 interlock circuits (4 N.O. and 4 N.C.) easily front-mounted

Permanent air-gap lengthens magnet life

New coil holder simplifies coil change

All parts front-mounted for easy service and maintenance

The highest degree of accessibility, flexibility and compactness—with no sacrifice of performance and long life. That's Square D balanced design—and you'll find it in every size Square D starter.

"Off-the-Shelf" Parts Kits, another Square D convenience feature, make normal maintenance easier than ever. Each kit contains parts to replace all load contacts and finger springs. Electrical interlocks also available in kit form.

Write for Bulletin 8536, Square D Company,
4041 North Richards Street, Milwaukee 12, Wisconsin

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

SQUARE D COMPANY

All Air-Cooled Dry-Type Transformers are NOT Alike

This was proved by tests, comparisons and experiences

THAT there is a difference in dry-type transformers was revealed in the findings of a survey made by *Plant Engineering*, a trade publication, which mailed 500 questionnaires to users of dry-type transformers. (A copy of this survey report will be sent on request.)

Most of the users who returned questionnaires reported having very favorable experiences with air-cooled dry-type transformers. A number of unfavorable reports listed the following reasons: "Some makes won't even handle their rating." "Some are very noisy." "Primary shorts." "The insulation breaks down without overload in relatively short time." Some recommended "mounted lugs for connections."

The unfavorable comments above *do not apply* to Sorgel air-cooled dry-type transformers.

SORGEL air-cooled dry-type transformers are guaranteed to carry the full rated load continuously, and are so liberally designed that they can safely carry an overload during an emergency. They are well known for their quiet operation. All are equipped with solderless terminal lugs.

Because these superior features cost more to incorporate in Sorgel air-cooled transformers, our price may not always be the lowest; however, the little additional price you might sometimes pay will be saved several times over in extra service and lower installation costs.

We spare nothing to maintain the highest quality in our air-cooled dry-type transformers.

SORGEL air-cooled dry-type transformers are top quality, time-tested, and are therefore recognized and accepted by discriminating engineers and users.

These transformers are available in a large variety of sizes and types for every purpose. 1/4 Kva to 1000 Kva single phase. 1 Kva to 3000 Kva 3-phase. All standard voltages, such as 120, 208, 240, 480, 600, 2400, 4160, 4800, 7200, 13,200, and up to 15,000 volts, and any intermediate or special lower voltages.

SORGEL dry-type transformers are also incorporated in substations, complete with primary and secondary switchgear.

The Sorgel Electric Co. has nearly 40 years of continuous experience in the development, manufacturing and application of dry-type transformers.

Stock carried by jobbers in the following cities:

Chicago, Illinois
Cleveland, Ohio
Los Angeles, Calif.
Milwaukee, Wis.
Rock Island, Illinois
Rockford, Illinois
Richmond, Indiana
Davenport, Iowa
Cedar Rapids, Iowa
Omaha, Nebraska
Roxbury, Mass.

Consult the classified section of your telephone directory or communicate with

SORGEL ELECTRIC COMPANY
846 West National Ave., Milwaukee 4, Wis.

(*Continued from page 18A*)

by the General Electric Company's welding department. Designated as G-E Type *WR40A*, the new welder can be equipped to operate on a 2-phase power and has a current welding range of 70 to 500 amperes. It can be utilized with a variety of electrode sizes for repair, maintenance, and construction work. Instant arc welding is assured since there is no inductive time lag as usually found in motor-generator sets. Because of the high current produced by the six parallel-path selenium rectifiers in the new unit, stable arcs and resulting smoother welds are made possible. The new welder is operable on 220–440 volts reconnectable to either voltage. It is also available with full-time arc force control which minimizes popouts and freezing-in.

Pen Lifter. An automatic pen-lifting device has been designed for single-record strip chart recorders, the Industrial Division of Minneapolis-Honeywell Regulator Company recently reported. A special rod and lever arrangement, operated by a solenoid, raises the pen clear of the chart depending upon the requirements of the application. For example, it can raise the pen either during "off" periods to prevent ink blots; during periods of either chart when the changing or when the chart is torn off the recorder; or when the measured variable falls below any selected value. The pen lifter can be wired so the pen automatically is lifted clear of the chart when the chart motor is turned off. For test cell applications terminals can be provided at the rear of the instrument for external wiring in order that the customer remotely may operate the chart drove switch and pen lifter solenoid. It can be particularly useful on the firm's Function Plotter where a series of records may be made on the same chart. The pen lifter will prevent the pen from marking the chart during retrace.

UHF Germanium Mixer Diodes. Ultra-high-frequency germanium mixer diodes are now available in production quantities from International Rectifier Corporation of El Segundo, Calif. Each unit is manufactured from specially treated, single-crystal germanium to assure maximum uniformity of characteristics. They are designed for circuit frequencies up to 3,000 mc per second with exceptionally low noise figure of 10–14 db at 500 mc. Type *G02* is for solder-in applications where space is limited and at a premium. Type *G02A* may be used as either a clip-in or solder-in unit. Both diodes are capable of withstanding severe shock and vibration as well as extreme atmospheric conditions due to the excellent quality control maintained in production and their ruggedized construction. For further information on these diodes, write Department 1A for Bulletin *ER-190* on company letterhead.

Electric Chopper. Avion Instrument Corporation, a division of American Car

(*Continued on page 26A*)

ids operation of the West's big new ower plant at Pittsburg, California

Building ahead of demand to satisfy all requirements for power in the thriving Northern and Central California regions, this new 600,000 KW power plant nearing completion at Pittsburg, California, is another milestone in the $1½ billion postwar construction program of the Pacific Gas and Electric Company.

It's the biggest in the West—an $80,000,000 project.

Engineered and constructed to give adequate, uninterrupted power to this important region, only the most reliable materials and equipment would do. Engineers of P.G.&E. and Bechtel Corporation, Engineering and Construction Contractors on the project, approved Rome power and control cables. Previous experience with Rome cables had been gained in the building of the Contra Costa Steam Plant and other P.G.&E. plants and stations.

Aluminum Power Cables

Miles of Rome "RoZone-RoPrene" aluminum 5KV and 600 volt auxiliary power cables and copper control cables have gone into this new Pittsburg Station.

Cables with ozone-resistant insulation and neoprene sheaths were specified for this installation. RoZone is the ozone-resistant oil-base insulation developed in the Rome Cable laboratories for long service under severe conditions. It has excellent electrical properties, and exceptional stability in water. It shows remarkable resistance to ozone, moisture, and heat. Its dielectric strength exceeds 400 volts per mil.

RoPrene is the tough Neoprene sheath that protects these cables so effectively against abrasion and other mechanical damage, and that makes them so easy to pull into ducts and conduits.

Ionization Level Tested

Every foot of Rome power cable rated at 3000 volts or over is subjected to ionization testing as a standard control procedure. In this non-destructive test, devised by Rome Cable engineers, the corona level of the entire cable is measured to make sure that the ionization voltage exceeds the intended operating voltage of the cable. This assures dependable service and long life, with correspondingly lower maintenance costs.

You can have the same assurance of quality and service, by specifying Rome cables. Write today for your copy of the Rome Power and Control Cable Catalog.

Approximately 37 miles of Rome copper control cables, and 12 miles of Rome aluminum power cables are among the products being used at Pittsburg plant.

One of the junction boxes at the Pittsburg plant, showing terminals of cables to busses.

It Costs Less to Buy the Best

ROME CABLE
Corporation
ROME • NEW YORK
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NOW

Precision Attenuation to 3000 mc!

TURRET ATTENUATOR featuring "PULL-TURN-PUSH" action

SINGLE "IN-THE-LINE"
ATTENUATOR PADS
and
50 ohm COAXIAL
TERMINATION

FREQUENCY RANGE:
dc to 3000 mc.
CHARACTERISTIC IMPEDANCE:
50 ohms
CONNECTORS:
Type "N" Coaxial female fittings each end
AVAILABLE ATTENUATION:
Any value from .1 db to 60 db
VSWR:
<1.2, dc to 3000 mc., for all values from 10 to 60 db
<1.5, dc to 3000 mc., for values from .1 to 9 db
ACCURACY:
±0.5 db
POWER RATING:
One watt sine wave power dissipation

Send for free bulletin entitled "Measurement of RF Attenuation"

•

Inquiries invited concerning pads or turrets with different connector styles

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California • Hollywood 4-9294

(*Continued from page 22A*)

and Foundry Company, 299–20 State Highway 17, Paramus, N. J., recently announced the Avion Electronic Chopper, Model *207*. This new unit operates on an entirely new principle involving the modulation of direct voltages by alternate illumination at line frequency, of the photoconductive element in a voltage divider. The advanced design offers several important advantages which include no drift, with no applied voltage; and no output whatsoever can be produced by any resistance changes. The noise amounts to less than 1 millivolt referred to the input. Where miniature size and long-life durability are important factors in the conversion of direct and alternating current, the performance characteristics of the new chopper are said to be ideal. Typical applications are in the fields of null measurement circuits, servomechanisms, computing devices, and other electronic control systems. Further information may be secured directly from the manufacturer.

Voltage Divider. The G. M. Giannini and Company, Inc., of East Orange, N. J., has announced a new and extremely stable voltage divider for use in both airborne and industrial electronic applications. The *85174* voltage divider offers uniform performance even when exposed to severe temperature changes, corrosive atmosphere, and high humidity. The unit is available with any number of voltage divisions up to 23, any spacing, and a maximum total resistance of 30,000 ohms. Resistance tolerance on each section can be held to +0.5 per cent of the section resistance. The new design incorporates such features as potting compounds for complete atmospheric protection and a single length of resistance wire. The latter feature produces a voltage ratio at the taps which is very stable with time aging and temperature. The temperature coefficient of the wire can be as low as +0.00002 or matched to any system wire.

Kel-F Insulated Wire. The Rex Corporation has announced unlimited color coding Kel-F insulated wire by use of striping in ten standard colors. Coding is extended further by varying the number and width of stripes. Previous coding was limited to only 15 solid colors, while striping makes over 2,000 combinations easily availabe. It is rated for continuous operation at 150 C at 1,000 volts, and in addition excels in every important insulation requirement. Although there has been an acute need for more extensive coding, the extreme chemical inertness of trifluorochlorethylene (known under the trade names of Kel-F and fluorothene) has made this extremely difficult. It is unaffected by the strongest acids, alkalies, oxidizing and reducing agents and by most solvents, and is very little affected by any solvent. Both Teflon and Kel-F insulation make good insulated wires. Each has its place, with Teflon at its higher price for the very high temperature applications,

(*Continued on page 36A*)

SOLDERED PORCELAIN
TYPE "ST" POTHEADS

These potheads are factory assembled, with metal-to-porcelain soldered joints. This method (exclusive with G & W) completely eliminates the possibility of future trouble due to loosely gasketed joints. When these potheads are used, the responsibility for properly sealed joints rests entirely with our factory. Troubles due to aging, cold flow and permanent set of gasket materials are eliminated.

Since their introduction in 1940, type "ST" Soldertite potheads have achieved an excellent service record on gas filled as well as standard cables. Many electric utilities companies have standardized the use of them.

Bulletin No. AA50 gives further information, data and prices.

Bulletin No. A52 explains the theory of stress cones and gives data on make-up as well as prices of material.

Write for your copies or ask your representative.

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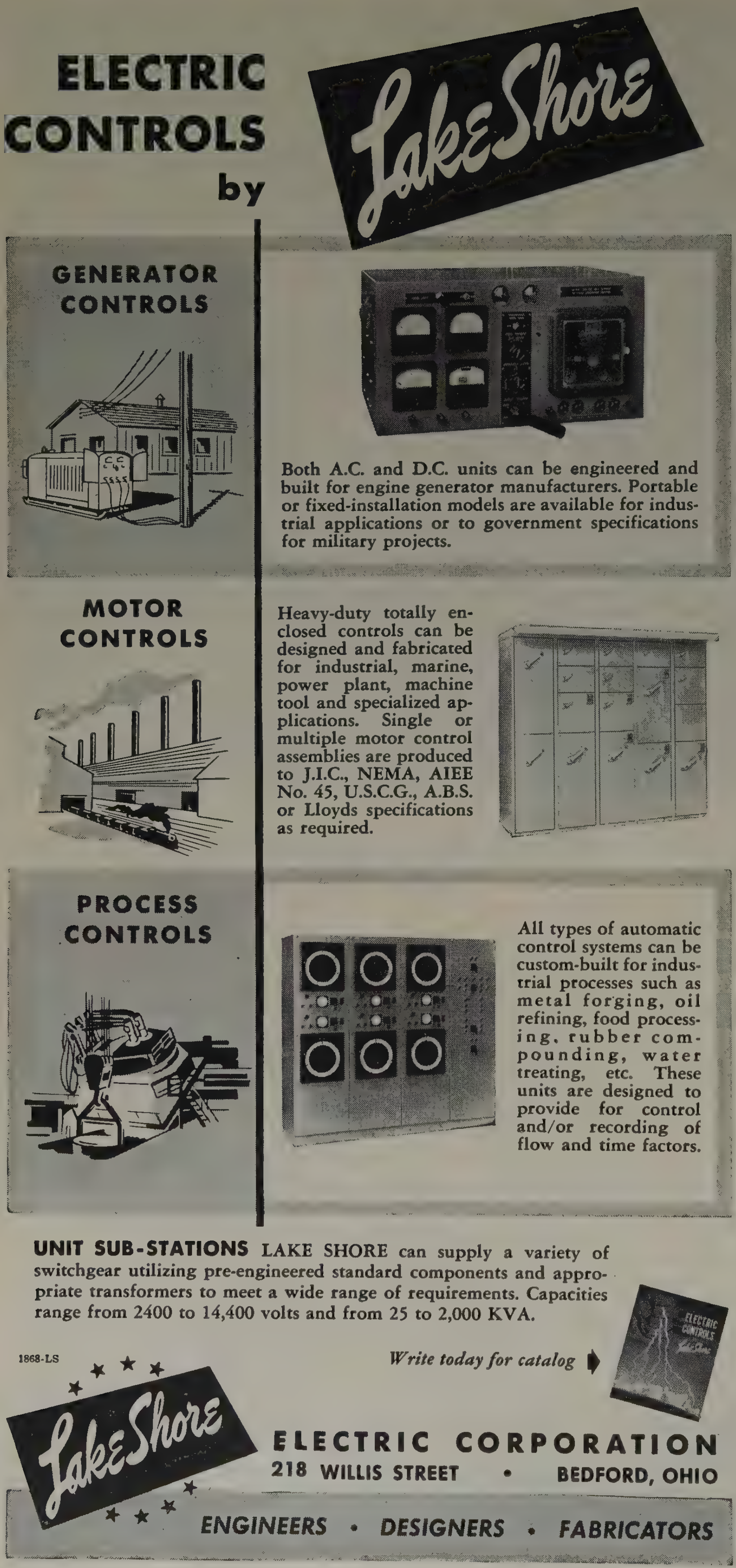
7780 DANTE AVE., CHICAGO 19, ILL., U.S.A.
Cable terminating, connecting and sectionalizing devices
Representatives in principal cities of U. S. A. In Canada — Powerlite Devices, Ltd., Toronto and Montreal



ELECTRIC CONTROLS by Lake Shore

GENERATOR CONTROLS

Both A.C. and D.C. units can be engineered and built for engine generator manufacturers. Portable or fixed-installation models are available for industrial applications or to government specifications for military projects.

MOTOR CONTROLS

Heavy-duty totally enclosed controls can be designed and fabricated for industrial, marine, power plant, machine tool and specialized applications. Single or multiple motor control assemblies are produced to J.I.C., NEMA, AIEE No. 45, U.S.C.G., A.B.S. or Lloyds specifications as required.

PROCESS CONTROLS

All types of automatic control systems can be custom-built for industrial processes such as metal forging, oil refining, food processing, rubber compounding, water treating, etc. These units are designed to provide for control and/or recording of flow and time factors.

UNIT SUB-STATIONS LAKE SHORE can supply a variety of switchgear utilizing pre-engineered standard components and appropriate transformers to meet a wide range of requirements. Capacities range from 2400 to 14,400 volts and from 25 to 2,000 KVA.

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ENGINEERS • DESIGNERS • FABRICATORS

(*Continued from page 26A*)

and Kel-F at a much lower price for practically all special requirement uses in its own temperature range.

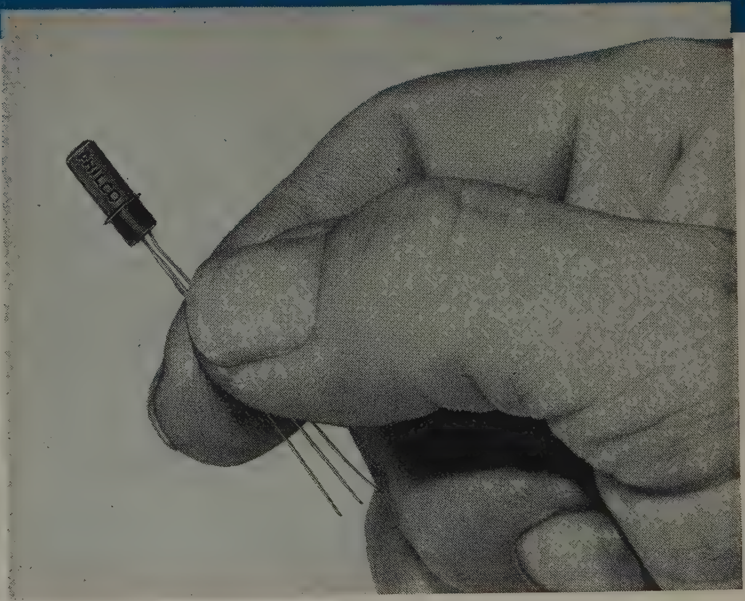
Multi-Purpose Electric Cable. A new low-cost, versatile cable for branch and feeder circuits on farms, in industry, and in homes, has been announced by the Rome Cable Corporation, of Rome, N. Y. This new cable, known as Rome FlexALL, is designed especially for underground feeder service, and for installation in locations where dampness or corrosive action are encountered. It is available in single-, 2-, and 3-conductor construction. Single-conductor Rome FlexALL is approved as Type *UF* (underground feeder), and 2- and 3-conductor constructions are approved as both Type *UF* and Type *NMC* (nonmetallic sheathed cable, corrosive resistant). Additional information on the Rome FlexALL cable may be obtained by writing to the Rome Cable Corporation, Rome, N. Y. Ask for Bulletin *RF-1*.

Receiving Tubes for Color TV. A special line of RCA electron receiving tubes for color television has been announced by the RCA tube department. The new tubes are specifically designed with operating characteristics necessary for critical circuit requirements of home color receivers and broadcast equipment. Although the new receiving tubes are specifically designed for color television use, they also have some applications in black and white television equipment and in electronic communications equipment. The tubes include a versatile two-in-one triode-pentode (RCA-*6AN8*), useful in at least eight different color-receiver applications; a sharp-cut-off beam triode for high-voltage regulator service (RCA-*6BD4*); a half-wave vacuum rectifier tube for high-voltage pulsed rectifier service (RCA-*3A3*); a pentagrid amplifier tube for gated amplifier service (RCA-*6BY6*); and a half-wave vacuum rectifier tube for damper applications (RCA-*6AU4-GT*).

Precision Film Resistors. A complete series of molded borocarbon resistors has been announced by the Sprague Electric Company. The new resistors, known as the Sprague Filmite *B* series, are the first to meet the severe performance requirements of Military Specification *MIL-R-10509A*, proposed Modification 2. The resistor, rated at 1/2, 1, and 2 watts, will dissipate full wattage ratings at an ambient of 70 C compared with the 40 C ratings on previous resistors of this type. Identified as Sprague Types *4E*, *5E*, and *6E*, the new resistors are molded in a dense plastic material, which not only provides unexcelled physical protection for the film resistance element but serves as a barrier for moisture and vapor. Sprague Engineering Bulletin *130*, which gives complete performance characteristics, physical sizes,

(*Continued on page 46A*)

PHILCO ANNOUNCES A REVOLUTIONARY NEW TRANSISTOR



New Diffused Alloy Junction Type Has Amazing Advantages . . .

Philco now presents to industry a new diffused alloy junction transistor with uniformity of characteristics never before attained in production.

Design engineers will welcome the predictable performance of circuits incorporating this superior transistor.

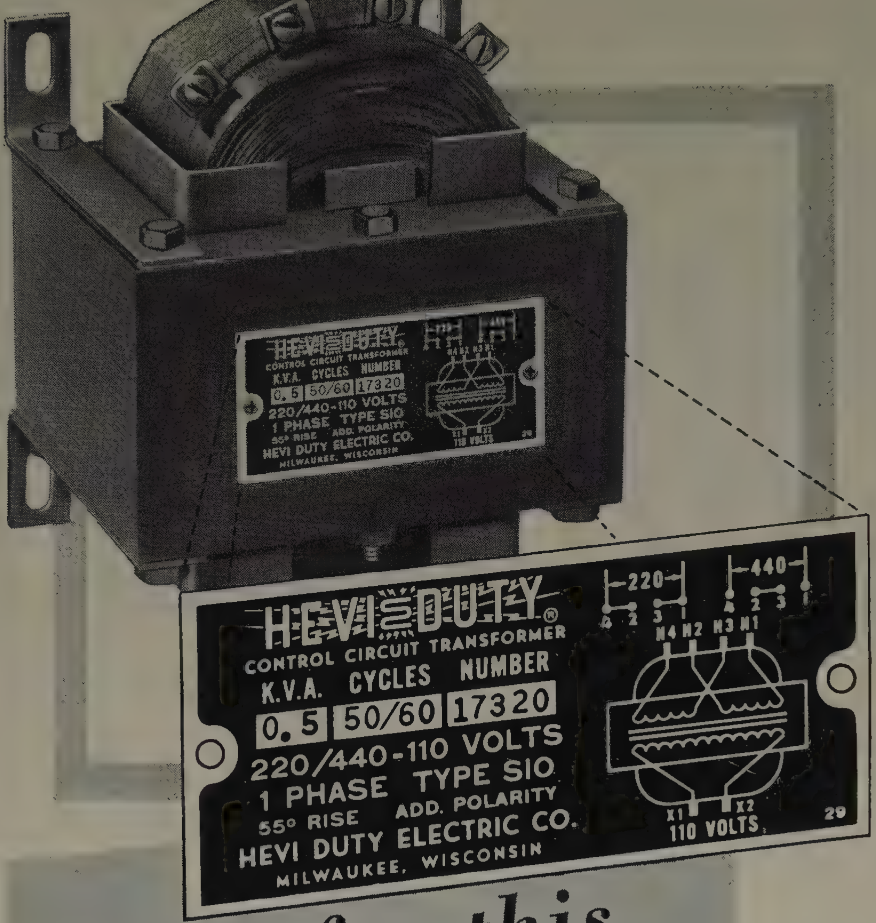
At last, here is a transistor that will operate with the same high degree of excellence in mass-produced units as in laboratory models—*eliminating the need for individual selection of transistors or associated components to meet equipment specifications!*

Now in production at Philco, this new transistor meets the high standards required for production applications. It is one of the smallest transistors ever produced. Leads are fused in glass—the entire transistor is enclosed in a metal envelope—an instantaneous resistance weld hermetically seals the complete unit. Advanced processing techniques and new mechanical design features assure excellent characteristics and uniformity throughout the life of the transistor. Phone, write or wire Philco today for descriptive literature and specifications on this revolutionary transistor.

- **Minimum size.**
- **Hermetically sealed, resistance-welded metal case . . . leads sealed in glass.**
- **Uniform characteristics.**
- **Designed to meet typical military environmental conditions.**

PHILCO
Famous for
QUALITY
the World Over

PHILCO CORPORATION
GOVERNMENT & INDUSTRIAL DIVISION • PHILADELPHIA 44, PA.



Look for this Sign of Quality

...on your

CONTROL CIRCUIT TRANSFORMERS!

It Assures HEVI DUTY Quality in a transformer Including These 4 Outstanding Features . . .

★ **LOW REACTANCE.** Interleaved windings give excellent voltage regulation at low power factor, high inrush loads.

★ **COMPACTNESS.** Saving valuable panel space, this Hevi Duty Transformer is able to do a better job than many larger transformers.

★ **HIGH DIELECTRIC STRENGTH.** Coils impregnated with acid and moisture resistant polymerizing varnish.

★ **TESTED** to NEMA and ASA Standards.

Terminal Connecting Type available in sizes from 30 VA to 10,000 VA. Complete information showing regulation curves, impedance characteristics, mounting dimensions, and other engineering data in Bulletin T-5111.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces . . . Electric Exclusively
Dry Type Transformers Constant Current Regulators

(Continued from page 36A)

and resistance ranges on these new resistors, is available on letterhead request to the Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

Digital Magnetic Tape Handler. Fast starts, fast stops, and high tape speeds are prime requirements for digital recording equipment. The new Potter Instrument Company Model *902* digital tape handlers meet these requirements with start and stop times of 5 milliseconds and tape speeds up to 60 inches per second. Extension of available tape width to 5/8 inch permits up to eight channels of information to be recorded simultaneously. Another important feature of the tape handler is the complete interchangeability of tape from one machine to another; tapes recorded on one tape handler can be played back on another. The new *902* handlers extend use of digital techniques to applications that previously had to be handled by more expensive but less effective methods. Information can be recorded as it is produced, continuously or intermittently, fast or slow, and stored indefinitely until needed. Then, it can be fed into a computer, printer, or punch card system at optimum speed for reduction, analysis, or control purposes.

TRADE LITERATURE

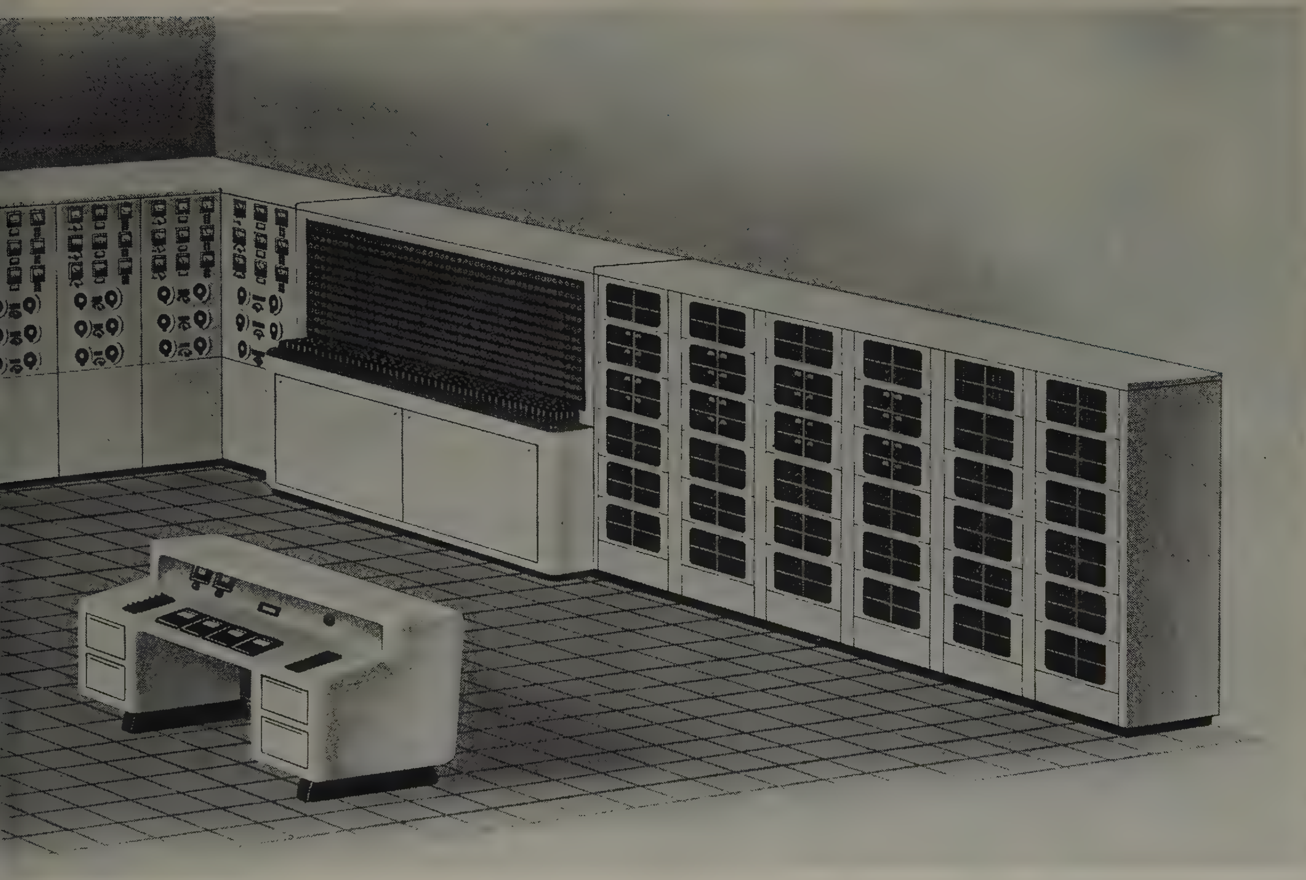
Control Centers. A colorful 24-page illustrated booklet issued by The Clark Controller Company, 1146 East 152d Street, Cleveland 10, Ohio, describes the many advantages of centralized electric control systems through use of their a-c motor control centers. Typical installations, specifications, construction details, and helpful planning tips also are featured. Invaluable reading for plant, project, or planning engineers and plant layout departments.

Power Fuse. A new catalogue section has been released by S&C Electric Company covering their Type *HSO* power fuse. The Type *HSO* is a boric acid fuse of medium interrupting capacity for application on circuits through 34,500 volts, where cutout protection is inadequate. It is a fuse of the dropout type using an inexpensive refill unit, available in 1-, 2-, or 3-shot styles, and is now available on a single insulator for crossarm mounting. Copies of the newly released Catalogue Section *250* can be obtained by addressing S&C Electric Company, 4435 Ravenswood Avenue, Chicago 40, Ill.

Multiple-Generator Sectional Drives. A new bulletin on multiple-generator sectional drives for paper machines has been

(Continued on page 50A)

# of POWER SYSTEM ANALYZERS



- 60 CYCLE POWER SUPPLY
- GREATER ACCURACY
- FASTER OPERATION
- COMPACT DESIGN
- MINIMUM MAINTENANCE
- SIMPLIFIED INSTALLATION

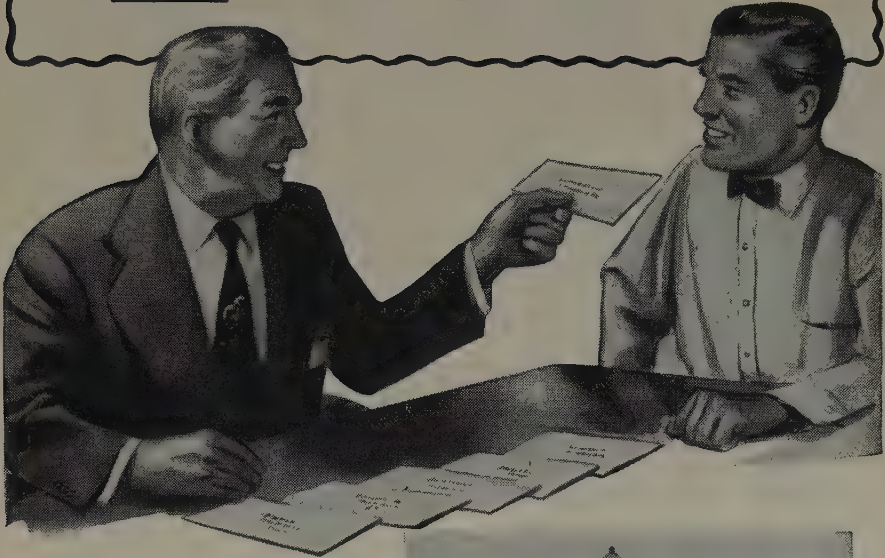
For details, contact the I-T-E Field office nearest you. Look in your Classified Directory under "Electric Equipment."

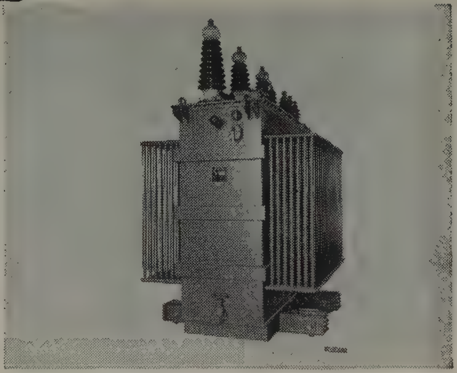
The Symbol of Quality Switchgear

I-T-E CIRCUIT BREAKER COMPANY
19TH AND HAMILTON STS., PHILADELPHIA 30, PA.

SYSTEM ANALYZERS

"I'll bet you NIAGARA TRANSFORMERS have won it . . . *before* we even open these bids"





NIAGARA 2500 KVA, 60 cycle, three phase, 66,000Y-13,200 delta volt, oil-immersed self-cooled transformer with wheels for movement in one direction, and bushing current transformers for differential protection.

Because of our compact organization and "team" production plan, many specifications are *not* considered "specials" by our estimators. However, this is not true of most transformer manufacturers and the result is that we win many quoted jobs on this factor alone. This is made possible by the fact that you deal *directly* with the people who will be responsible for the pricing, designing, engineering, manufacturing and shipment of your units. No red tape to cut! This is just part of our usual friendly cooperation.

Add this to Erie Electric's well earned reputation for reliability, the dependable performance of every Niagara Transformer and the fact that we can usually arrange our shop schedule to suit YOUR convenience and . . . you have some mighty good reasons for asking Erie to quote on your next transformer.

Send for this FREE BOOK!

Get acquainted with all the plus values in a Niagara Transformer. Write on your letterhead for this big, fully illustrated and informative book.

ERIE ELECTRIC CO., INC., 114 CHURCH ST., BUFFALO, N. Y.
OFFICES IN ALL PRINCIPAL CITIES
POWER • LIGHTING • LOAD CENTER • OIL-IMMERSED • DISTRIBUTION • UNIT SUBSTATION • DRY-AIR COOLED • NON-INFLAMMABLE

(*Continued from page 46A*)

announced as available from the General Electric Company, Schenectady 5, N. Y. The 8-page publication, designated *GEA-5712A*, points out the flexible versatility of the sectional drives by providing information on installation, operation, maintenance, adaptability, and service. Material on other types of General Electric paper machine drives also is provided.

Hints on Vacuum Pump Care. Dozens of practical tips on installing, operating, and maintaining vacuum pumps and vacuum systems are contained in "How to Care for Your Vacuum Pump," a new 16-page handbook issued by F. J. Stokes Machine Company, Philadelphia, Pa. Included in the manual are: the proper way to make leakproof connections in vacuum piping layouts; recommended types of gauges, valves, fittings, and gaskets; step-by-step trouble-shooting procedures to be followed when the pump is knocking, will not start, or will not produce a satisfactory vacuum; and some "do's" and "dont's" to insure long and trouble-free service life of vacuum systems. Copies are available on request from F. J. Stokes Machine Company, 5500 Tabor Road, Philadelphia 20, Pa.

Oscillographic Recording Systems. A new 38-page catalogue which describes Sanborn oscillographic recording systems and accessories for industrial use has been released. Illustrations, technical data, and specifications are included for Sanborn 4-, 2-, and 1-channel recorders as well as for the highly versatile new "150" series systems. The new catalogue may be obtained without obligation by writing to Sanborn Company, Industrial Division, 195 Massachusetts Avenue, Cambridge 39, Mass.

Engine-Type Synchronous Motors. Standard construction features of Allis-Chalmers engine-type low-speed synchronous motors in ratings of 100 hp and larger at speeds of 450 rpm or less are described in a new bulletin released by the company. Stator, rotor, and collector assembly features are described and illustrated in the bulletin. In addition, such modifications as extra flywheel effect, split rotor, and split stator are given. Copies of the bulletin, "Allis-Chalmers Engine-Type Synchronous Motors," *05B8008*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

Magnetic Contactors. Federal Electric Products Company, 50 Paris Street, Newark 5, N. J., has issued a new booklet, Bulletin *502*, describing Federal Noark magnetic contactors. Complete information including dimensions and weights are given. Bulletin *502* magnetic contactors are designed to provide a safe, dependable means for repeated quick closing and opening of the electric circuits controlling the sequence of operations in modern multiple-action machines.

(*Continued on page 56A*)

designer's INSTRUMENT guide

FOR PRODUCTION MACHINES— WESTON "per-cent load" ammeters and wattmeters make it easy for operators to secure optimum production from lathes, milling machines, automatics, grinders, etc. Prevent overloading—reduce tool breakage—assure uniform quality with fewer rejects. Other scale calibrations also available.

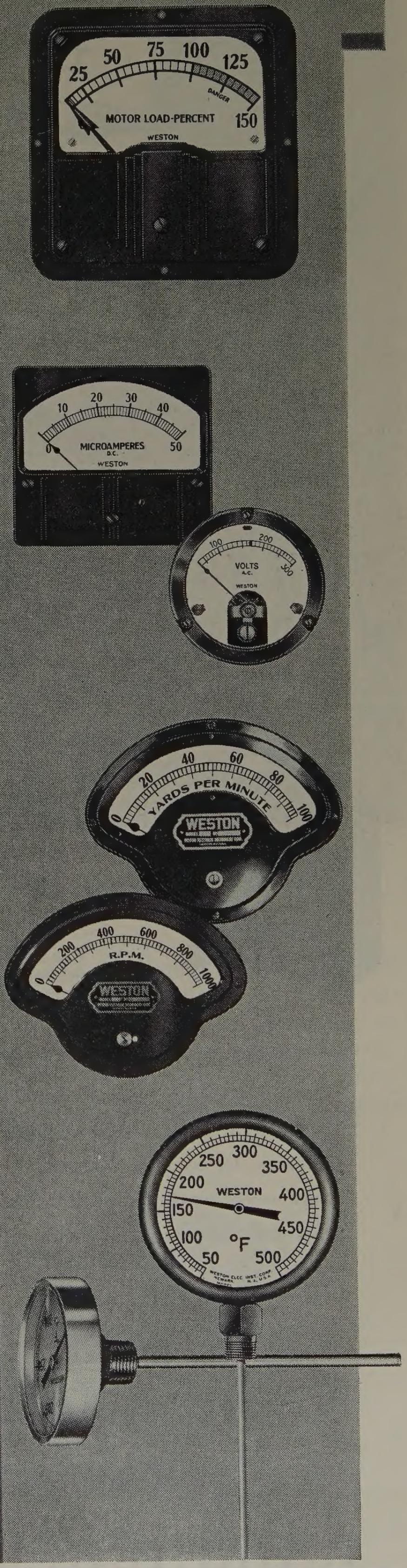
FOR ELECTRONIC EQUIPMENT— WESTON panel instruments are available in 1½", 2½", 3½", 4½" and 5½" sizes in all required ranges and types, including d-c, a-c, rectifier and thermocouple types. Approved ruggedized and sealed instruments available in all types in 2½" and 3½" sizes. Special panel bulletins give complete information.

FOR RPM MEASUREMENTS— WESTON electrical tachometer indicators are available with scales calibrated in RPM, or any function of RPM, such as feet per min.—pieces per hour, etc. Indicators can be mounted remotely; and if required, more than one indicator can be operated from one generator. Special compact, lightweight a-c and d-c generators permit wide flexibility in mounting and connection arrangements. Directly indicate speeds from 1 RPM to 40,000 RPM or higher.

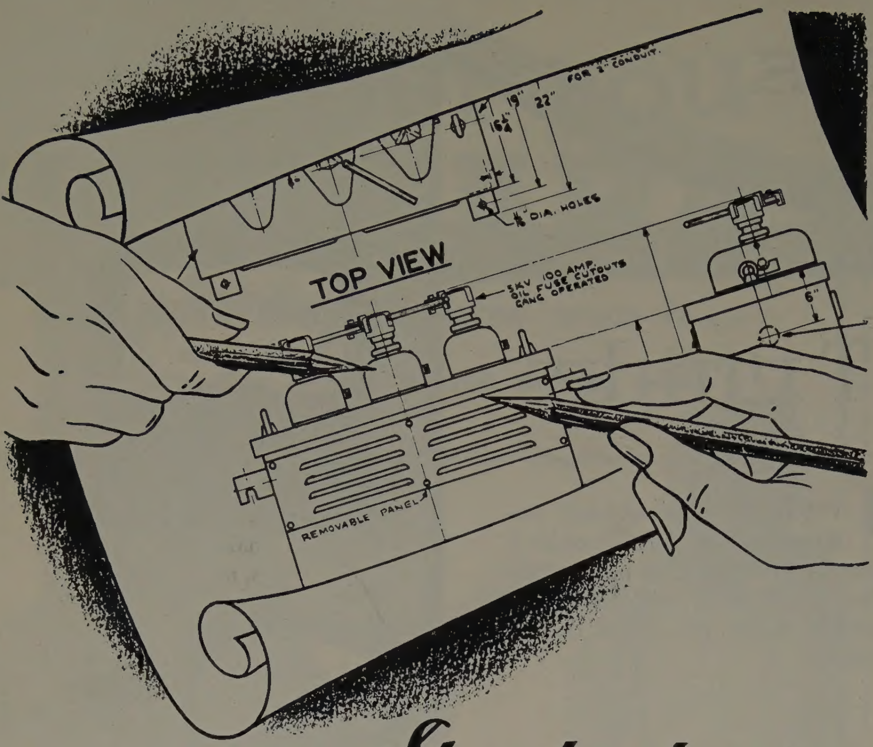
FOR TEMPERATURE MEASUREMENTS— WESTON Bi-metal thermometers are rugged and dependable, and are readily adaptable for built-in needs. Available in angle and straight stem types, stem lengths from 2" to 72", scale lengths 3.40" to 9", ranges low as −100°F. and high as +1000°F. Corrosion resisting stainless steel stems—accuracy 1% of thermometer range.

6402

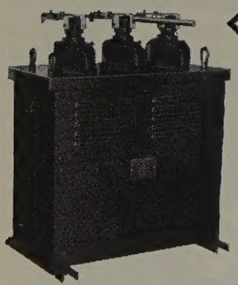
Literature on any of the above instruments sent on request.
WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.



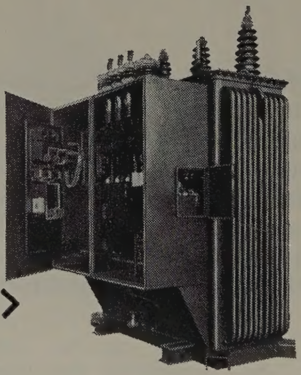
WESTON *Instruments*



Standard WORKS
TRADE MARK
WITH YOUR ENGINEERS WHEN YOU NEED Special TRANSFORMERS



25 KVA Dry Type Load Center Transformer with primary oil-filled fused cut-outs.



1000 KVA Special Unit Sub-Station — 66,000 to 2400 volts.

Working with you, STANDARD engineers can greatly assist in planning special transformer installations for a specific need in your plant. Experienced STANDARD engineers have an excellent understanding of the particular needs of the electrical industry. Custom-designed and built transformers are their specialty. There's a STANDARD TRANSFORMER representative near you. Call him today!

Standard
THE STANDARD TRANSFORMER COMPANY
Trade Mark ®

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

(*Continued from page 50A*)

Electronic Counter. Proved techniques for making common mechanical measurements quickly and accurately with electronic counters are described in a recent issue of the *-hp- Journal*, published by the Hewlett-Packard Company. Included in the issue are techniques for measuring operating time of high-speed clutches, rpm on very-high-speed shafts, stability of rotation, electric relay operating times, and phase delay in low-frequency devices such as servomechanisms. Volume 5, number 1–2, of the *-hp- Journal* may be obtained at no charge by writing Hewlett-Packard Company, Department P, 395 Mill Page Road, Palo Alto, Calif.

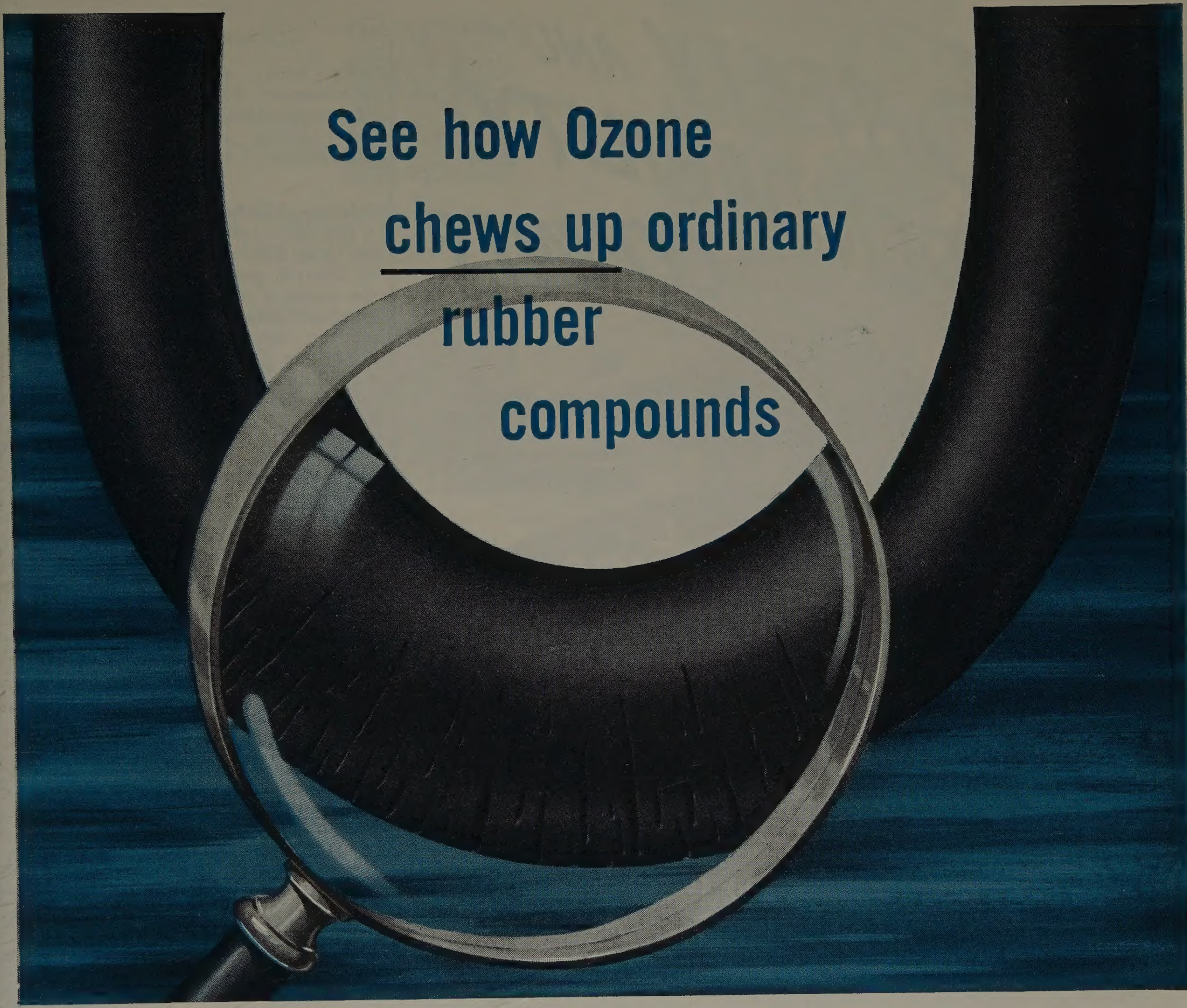
Power Transformer. Standardization of core-form power transformers is discussed in a new 40-page booklet available from the Westinghouse Electric Corporation. Technical in nature, this booklet relates developments in construction, materials, and operation of Type *SL* power transformers to the benefits the user derives from standardization of the various components. Besides covering the construction and operation characteristics, this booklet also describes the various standardized processes used during manufacture of a Type *SL* power transformer. For a copy of this reference-type booklet, *B-5914*, on Type *SL* power transformers, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

Crystal Handbook. A handbook of crystal and oscillator theory has been complied and published by The James Knights Company, Sandwich, Ill. It is intended as a handy reference for the design engineer using crystals. General performance data on cuts are provided, giving information on temperature coefficient and size factors. A bibliography is included for those who wish to make a more detailed study of the subjects involved. The "Crystal Handbook" is available at $1.00 per copy from The James Knights Company.

Transistor Literature. The wealth of existing literature on the characteristics and uses of the transistor has been organized for reference purposes by The Glenn L. Martin Company, Baltimore 3, Md., and is available for distribution on request by interested engineers. The "Guide to Transistor Literature" booklet cites well over 400 transistor papers pertinent to the work of the electronics engineer, for whom the bibliography is particularly intended. The entries have been classified for a quick rundown of all papers in particular fields: theory, application, circuits, and the like.

Remote Bulb Thermometers. A new 44-page catalogue is being offered by Minneapolis-Honeywell Regulator Company on remote bulb thermometers which covers selection data, recorders and indicators, pneumatic control, electric control, program control, psychrometers,

(*Continued on page 62A*)

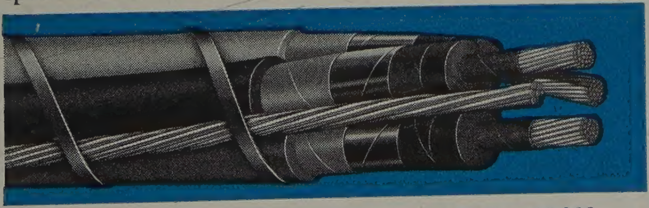


See how Ozone chews up ordinary rubber compounds

but not U. S. Grizzly Uskorona-insulated power cables

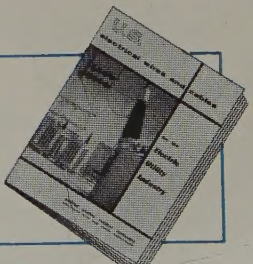
Here's an illustration showing how ozone can chew up a sturdy, rugged cable. This can never happen with United States Rubber Company's famous Grizzly® power cables, insulated with Uskorona® compound which prevents electrical failure caused by ozone (Uskorona-1 oil base compound and Uskorona-2 butyl base compound). Uskorona meets (and in many ways exceeds) the applicable IPCEA specifications for ozone-resistant rubber insulation.

U. S. Grizzly ozone-resistant power cables are typical of the wires and cables "U. S." develops to meet the ever-increasing rate of expansion of electrical generation and construction. "U. S." is always ready with new products to meet new demands and is always developing, as a matter of policy, wires and cables that are more economical because they are more serviceable.



U.S. Grizzly Uskorona-insulated Power Cable, 15,000 volts, Type RR, 3 conductor, shielded, Neoprene jacket

Send for free illustrated book giving full information about U. S. Electrical Wires and Cables for the Electric Utility Industry.



US RUBBER

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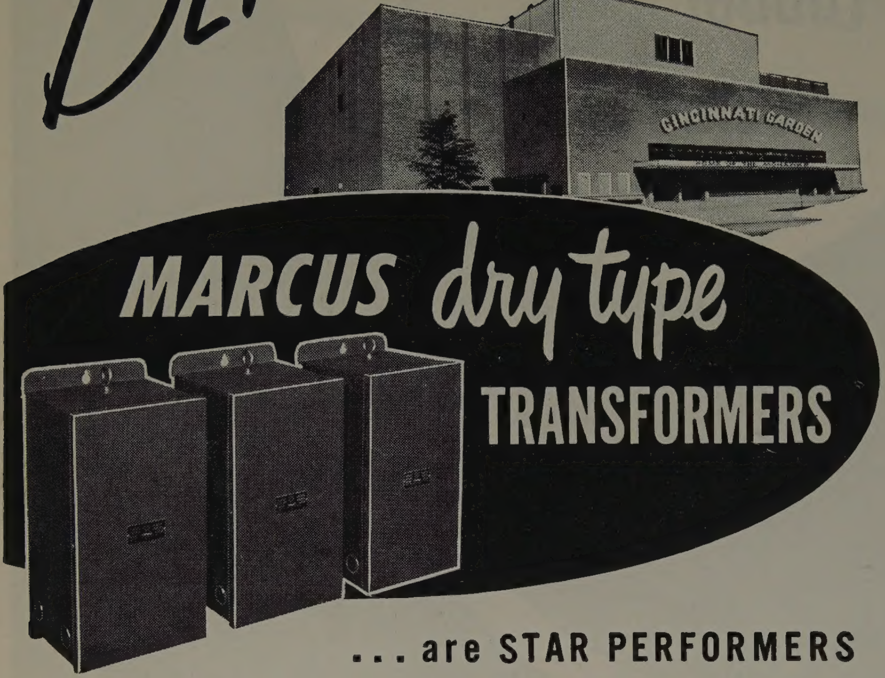
ELECTRICAL WIRE & CABLE DEPARTMENT, ROCKEFELLER CENTER, NEW YORK 20, N. Y.

WHERE SAFETY AND DEPENDABILITY COUNTS...



MARCUS dry type TRANSFORMERS

3 of the 19 Marcus transformers installed, with ratings up to 150 KVA.

... are STAR PERFORMERS at the Cincinnati Garden!

Feeding the power where and when needed at Cincinnati's huge and busy "Garden" is another important assignment for MARCUS Dry Type Transformers.

Because all Marcus Dry Type Transformers are now being constructed with Hi-Heat, Hi-Dielectric Magnet Wire, insulation levels of at least 10 times present industry standards are easily attained.

This factor alone, plus an enviable record of trouble-free performance and matchless dependability made Marcus Dry Type Transformers the choice of the Beltzhoover Electric Co., of Cincinnati, Electrical Contractors for the project, and A. M. Kinney, Inc. the consulting Engineer on the job.

Increase your power Performance Standards with Marcus Dry Type Transformers.

Capacities from 1 to 3000 KVA
- DISTRIBUTION
- GENERAL PURPOSE
- UNIT SUBSTATION
- PHASE CHANGING
- ELECTRIC FURNACE
- RECTIFIER
- WELDING
- MOTOR STARTING
- SPECIAL

MARCUS MTC

"Mark of Quality"

Representatives in Principal Cities

MARCUS
TRANSFORMER CO., INC.
HILLSIDE 5, NEW JERSEY

ONE OF THE WORLD'S LARGEST MANUFACTURERS OF DRY TYPE TRANSFORMERS EXCLUSIVELY

(*Continued from page 56A*)

bulbs, tubing, and fittings. For copies of catalogue *6709* address Station 64, Minneapolis-Honeywell Regulator Company, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Selenium Rectifiers for Color Television. A new folder entitled "Selenium Rectifiers for Color Television" has been published by Federal, providing information about the design of color television power supplies, and listing a special group of selenium rectifiers specifically adaptable to this application. The folders are available on request from the Selenium-Intelin Department, Federal Telephone and Radio Company, 100 Kingsland Road, Clifton, N. J.

Publication Available From Nuclear-Chicago. The fourth issue of the "Nucleus" has been released by the Nuclear Instrument and Chemical Corporation, 229 West Erie Street, Chicago 10, Ill. Articles in the issue describe new methods for counting radioactive iodine in the measurement of thyroid function, an article on radioisotope facilities in the general hospital, an article on isotope dilution analysis, and a description of Nuclear-Chicago's new radiochromatographic analyzer. Copies of this 8-page booklet will be sent on request.

IRE Power Resistors. Comprehensive data on characteristics, applications, construction, ranges, ratings, tolerance, charts, and graphs for the new IRE Power resistors, Types *PW-7* and *PW-10*, are available. For copies write International Resistance Company, 401 North Broad Street, Philadelphia 8, Pa., asking for catalogue data Bulletin *P-2*.

Measurements Based on Nuclear Radiation. Instrumentation Data Sheet *10.0-15* describes industrial instrumentation applications of the Ohmart cell; the unique radioactive sensitive element which converts nuclear radiation directly into electric energy. Used with a Brown Electrometer and a null balance type of measuring circuit, it permits extremely accurate measurement of film thickness, density, specific gravity, liquid-liquid interface level, density, concentration of alpha, beta, gamma, or neutron radiation, and the composition of binary gas systems. Complete description of the Ohmart cell models and the Brown Electrometer are included with application detail. Address requests to Station 64, Minneapolis-Honeywell Regulator Company, Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Switches. A 12-page 2-color Catalogue Number 90 on Honeywell Mercury Switches has been published by Micro Switch, Freeport, Ill., a Division of Minneapolis-Honeywell Regulator Company. This catalogue covers standard designs of Honeywell Mercury Switches for use in a-c or d-c industrial and commercial switching applications that provide low force and tilt motion. A complete section on technical data and application aids is included.